JULY 1943

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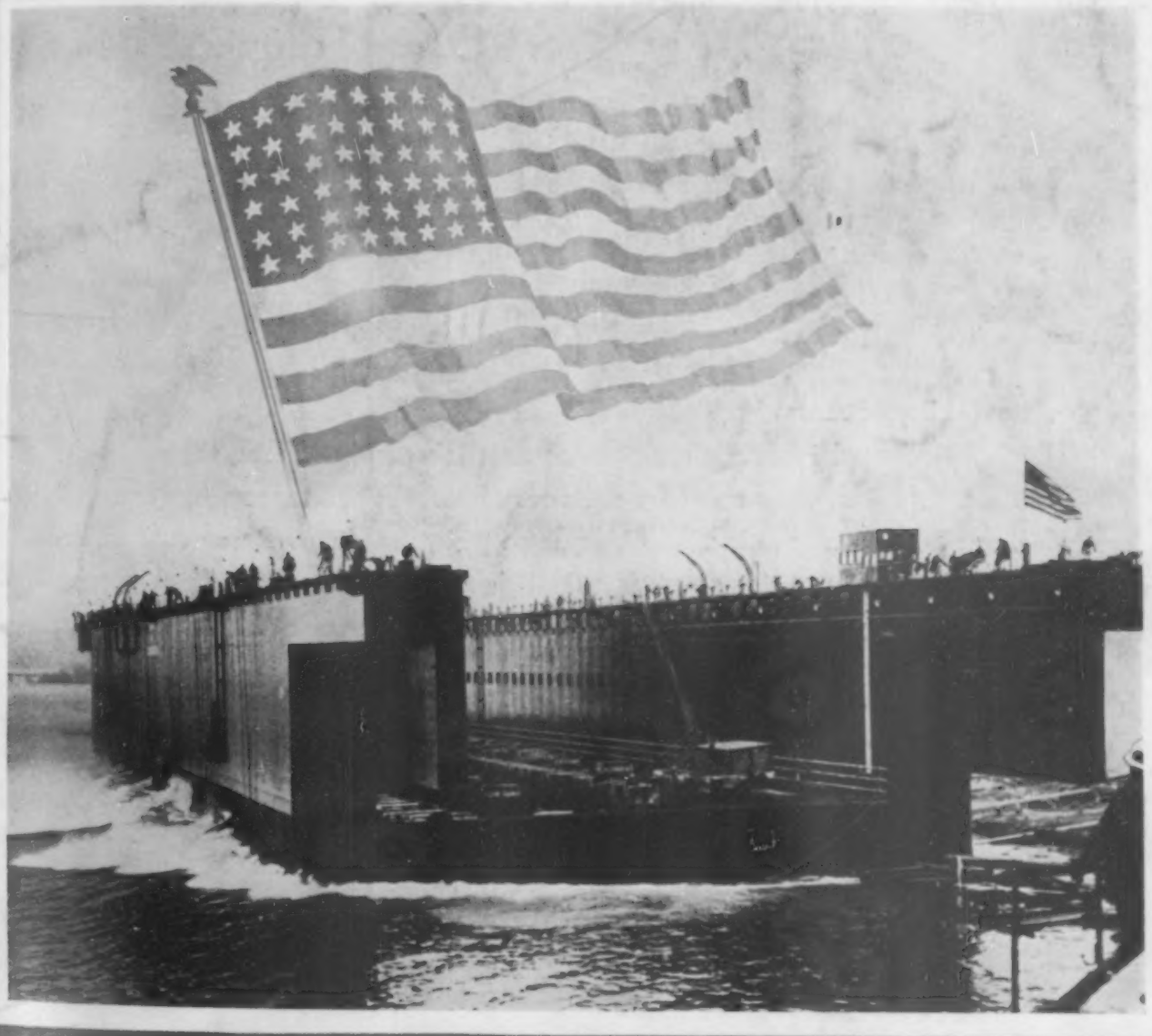
The WELDING Journal



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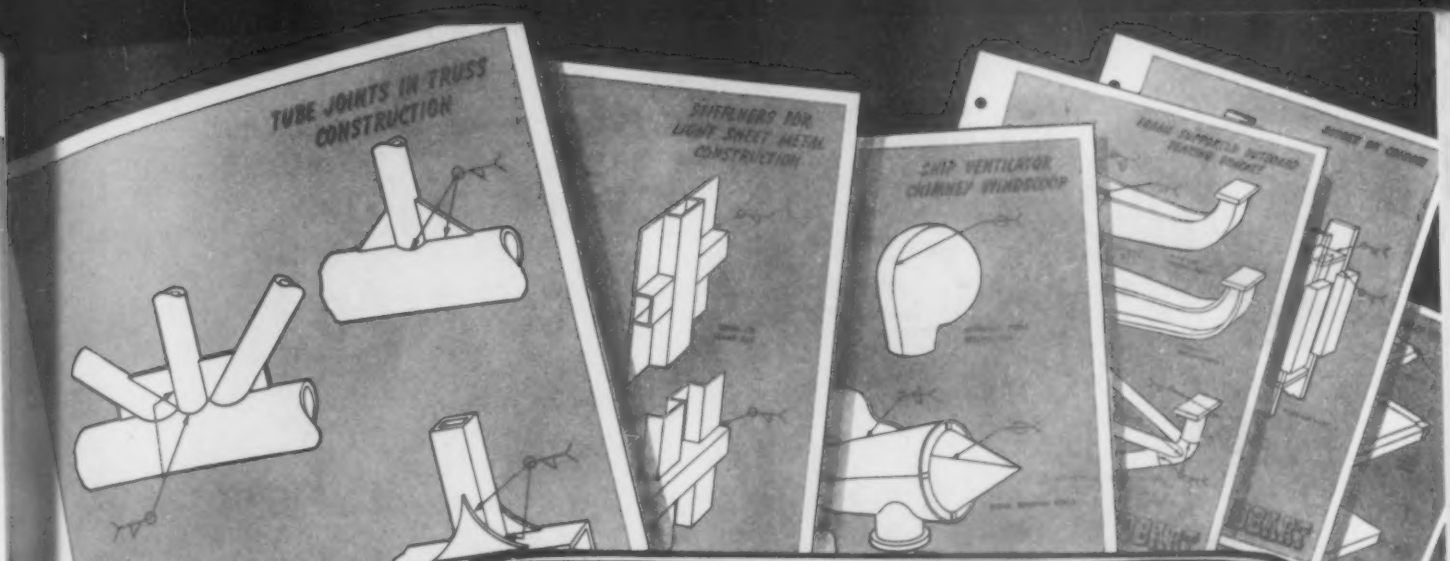

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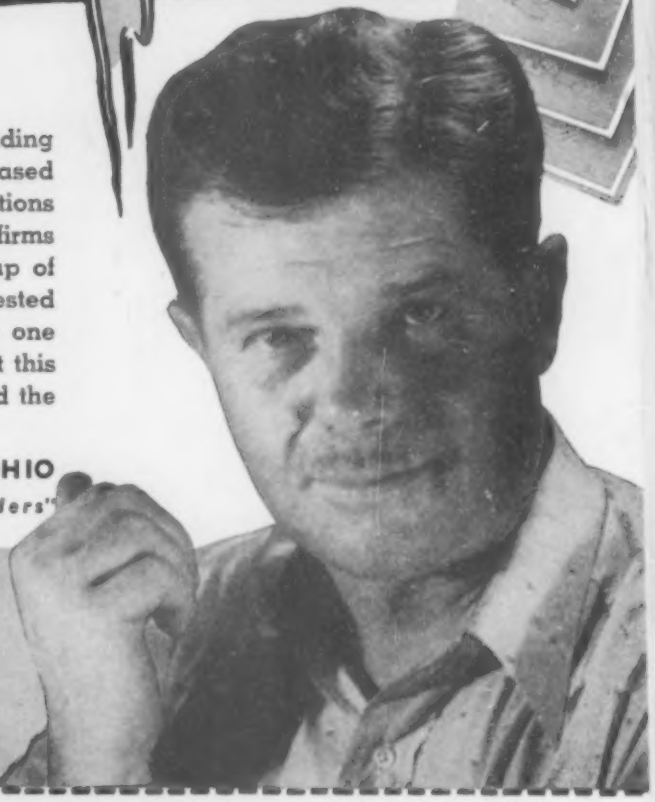

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Center Section — 18,000 Ton All-Welded Steel Floating Dry Dock. *Courtesy Chicago Bridge & Iron Company.*

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CONTENTS

TECHNICAL PAPERS, ITEMS AND REPORTS

Wheel Mounting Bracket for Four-Wheel Drive Racing Automobile, by E. W. Jacobson and F. F. Versaw 499

Current Welding Literature 503

Adaptation of Welded Steel to the Paper Machine, by R. S. Conabee 504

New Design of Fuel Oil Heaters Conserves Material, by H. S. Card 513

Residual Stresses in Welded Structures, by Robert E. Kinkead 514

Working Out Techniques for Welding Armor Plate, by E. G. Biederman 516

Skill and Ingenuity of Arc-Welding Job Shops Shown in Production of Numerous Small Items, by C. M. Taylor 520

Proposed Code of Minimum Requirements for Instruction of Welding Operators, Part B-1—Oxyacetylene Welding of Steel-Aircraft 522

SOCIETY AND RELATED ACTIVITIES

By-Law Amendments 546

Draft of By-Laws Suggested for a Student Chapter of the A.W.S. 548

Index to Advertisers 550

Members in Armed Forces 552

Professional Personnel 552

Handbook for the Welding and Cutting Operator 552

Ratings Show Usable Welding Current 554

List of Standards 554

Welded Locomotives 557

1943 A.S.T.M. Symposium on Radiography 557

Tips on Arc Welding 557

Silver Brazing Bulletin 557

Army-Navy "E" to United Welding Co. 557

Aluminum Castings Salvaged 558

Gordon Joins Detroit Electronic Laboratory 558

Speeding Erection of Boiler Stacks 558

New Manual of Welded Heat Exchanger Tubing 558

Power for War Plants 560

Training Film "The Inside of Atomic-Hydrogen Arc Welding" Now Available 560

New Electrode Index Simplifies Comparison 562

Women Workers 562

Servicing Safety Equipment 562

Arc Welding Quartet 564

Designed for Close Quarters 564

Notice of New Zone Address 564

Turning Rolls 564

New Products 566

Spot and Seam Welding Data for Low Carbon Steels 572

New Template Book Aids Pipe Fitting 572

List of New Members 574

Members Reclassified 576

Section Activities 578

Employment Service Bulletin 580

Board of Directors Meeting 581

Sections—Chairmen, Secretaries and Regular Meeting Dates 582

WELDING RESEARCH SUPPLEMENT

Research Work in Welding at the University of Illinois 273-s

A Tentative System for Preserving Ductility in Weldments, by Gilbert E. Doan and Robert D. Stout 278-s

Tests on NE 8630 Steels for Welded Air Frames, by Morse Hill 300-s

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Wheel Mounting Bracket for Four-Wheel Drive Racing Automobile*

By E. W. Jacobson† and F. F. Versaw†

THIS paper describes how use of arc welding solved a very difficult design problem in the wheel mountings in a frame for a racing car. The nature of the problem was such that only by using arc welding could a satisfactory design incorporating the necessary lightness, extremely high strength, compactness and reasonable cost be achieved. The authors hope that the procedure outlined will prove to be a valuable guide in fabrication of similar highly stressed structures not only in the field of special-purpose automotive frames, but possibly in aircraft parts where light weight and high strength are of prime importance.

The arc-welded wheel mountings discussed in this paper were a vital part of two special race car frames designed to mount a pair of high-output, high-speed automotive-type engines for use in the Indianapolis Memorial Day auto race. Figures 1 and 2 show views of a right front wheel-mounting bracket. Figure 3 shows the parts which were arc welded together to form this bracket. Figure 4 shows the parts before assembly into the frame. Figure 5 shows the completed frame. Figure 6 shows a front view of the completed chassis. Figure 7 shows the rear view of one of the completed racing cars. These engines were mounted in four-wheel drive chassis with individually sprung wheels. On the frame first used with this type engine, the fuel tanks had been mounted outside the main frame side channels. For the 1941 race, the speedway officials ruled that these tanks must be protected either by mounting within the boundary of the frame or inside of the frame side rails themselves.

The frame design selected was that using a box girder section side rail, housing two fuel tanks, one just forward and one just back of the center cross member with the arc-weld fabricated wheel mountings in each end of these box girder side rails. The design which this replaced used a channel-shaped side rail with steel-casting wheel mountings at either end of each rail. The new frame was required to have a weight comparable to the old simple side rail design and to provide mountings for the wheels, engine, etc., which were already made. The new arc-weld fabricated wheel mountings herein described were the most vital part of this box girder frame.

The stress picture in the wheel mountings were complicated by several factors. Each of the front wheel mountings was bolted directly to an aluminum differential case which tied the front of the frame together. The rear wheel mountings bolted to the transmission case which was integral with the engine assembly. The wheels, which were all four individually driven, were suspended from the wheel mountings by two radius arms each. These radius arms, which were supported by pivot shafts with needle bearings in the arc-welded mountings, carried all the stresses arising from the wheels, directly to the wheel mountings. These transmitted

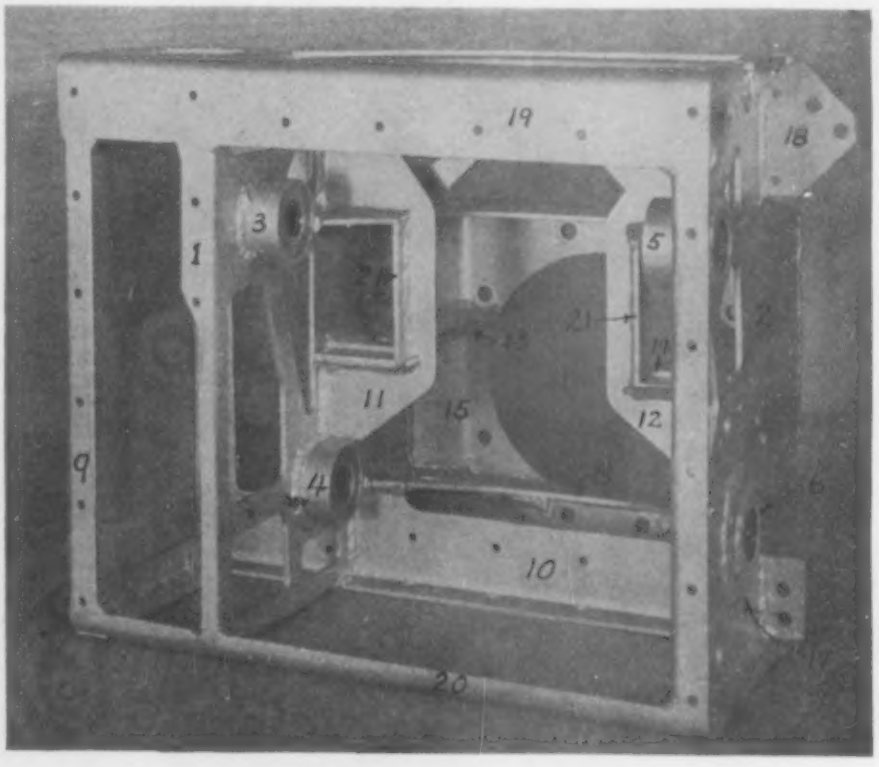

Fig. 1—Right Front Mounting Bracket, Car No. 105

* Third Prize Award Paper in the Automotive Frames A 3 Division of the 1940–42 Industrial Progress Award Program sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland, O.

† Design Engineer and Shop Superintendent, respectively, Gulf Research & Development Co., Pittsburgh, Pa.

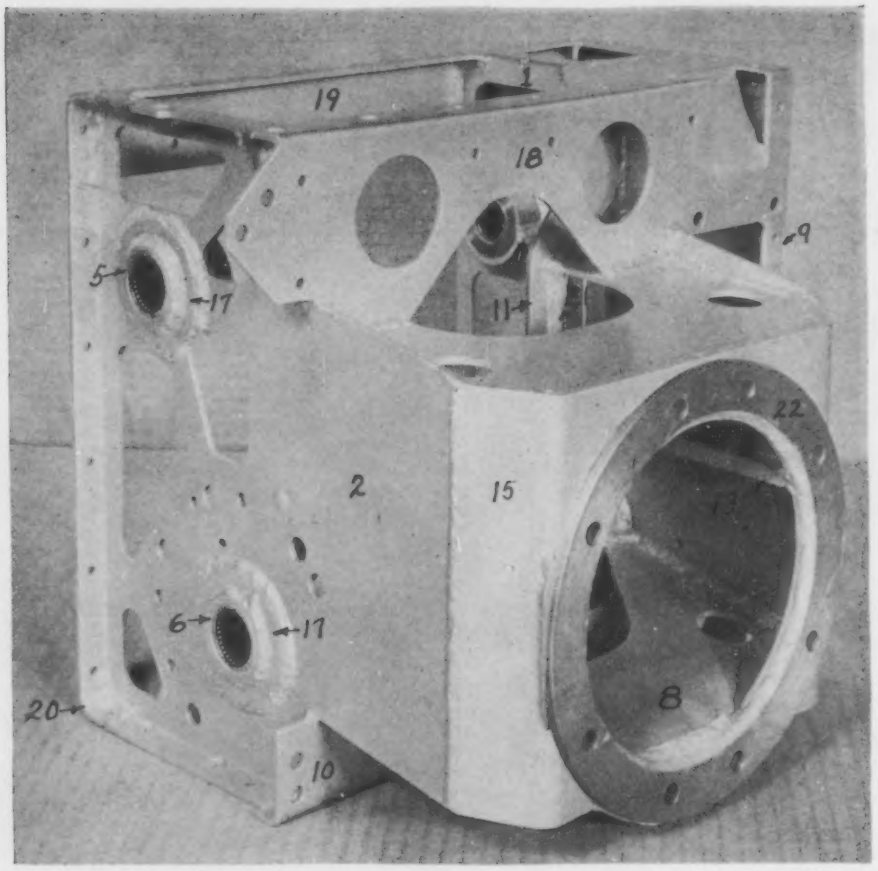

Fig. 2—Right Front Mounting Bracket, Car No. 105

stresses arose from any one or a combination of the following:

1. Torsional load arising from application of the wheel brakes.

2. Horizontal bending and thrust loads due to the wheels driving the car forward.

3. Horizontal bending and thrust loads due to the wheels slowing up the car when the brakes were applied.

4. Horizontal bending and thrust loads due to the wind-up between the front and rear wheels when going around curves. There was no differential action provided between the front and rear wheel drives, so that when on curves the wheels, each rolling on a different radius, would turn at different rates for short periods. This tended to produce forces which would try to change the center distance between the front and rear wheels to compensate. The forces would build up until tire slippage relieved them.

5. The inner ends of the two cantilever springs on each wheel placed high stresses in the spring support pads.

6. Each upper radius arm pin was keyed to the radius arm and was lever-connected to a hydraulic shock absorber, which in turn was fastened on the wheel mounting (see Fig. 6).

7. Each lower radius arm pin was connected to a friction type shock absorber which was also bolted on the wheel mounting (see Fig. 6).

8. The front brackets carried the steering gear supports and thus absorbed all the steering loads.

9. The rigidity and stiffness of the box type frame section tended to centralize the shock loads in the highly

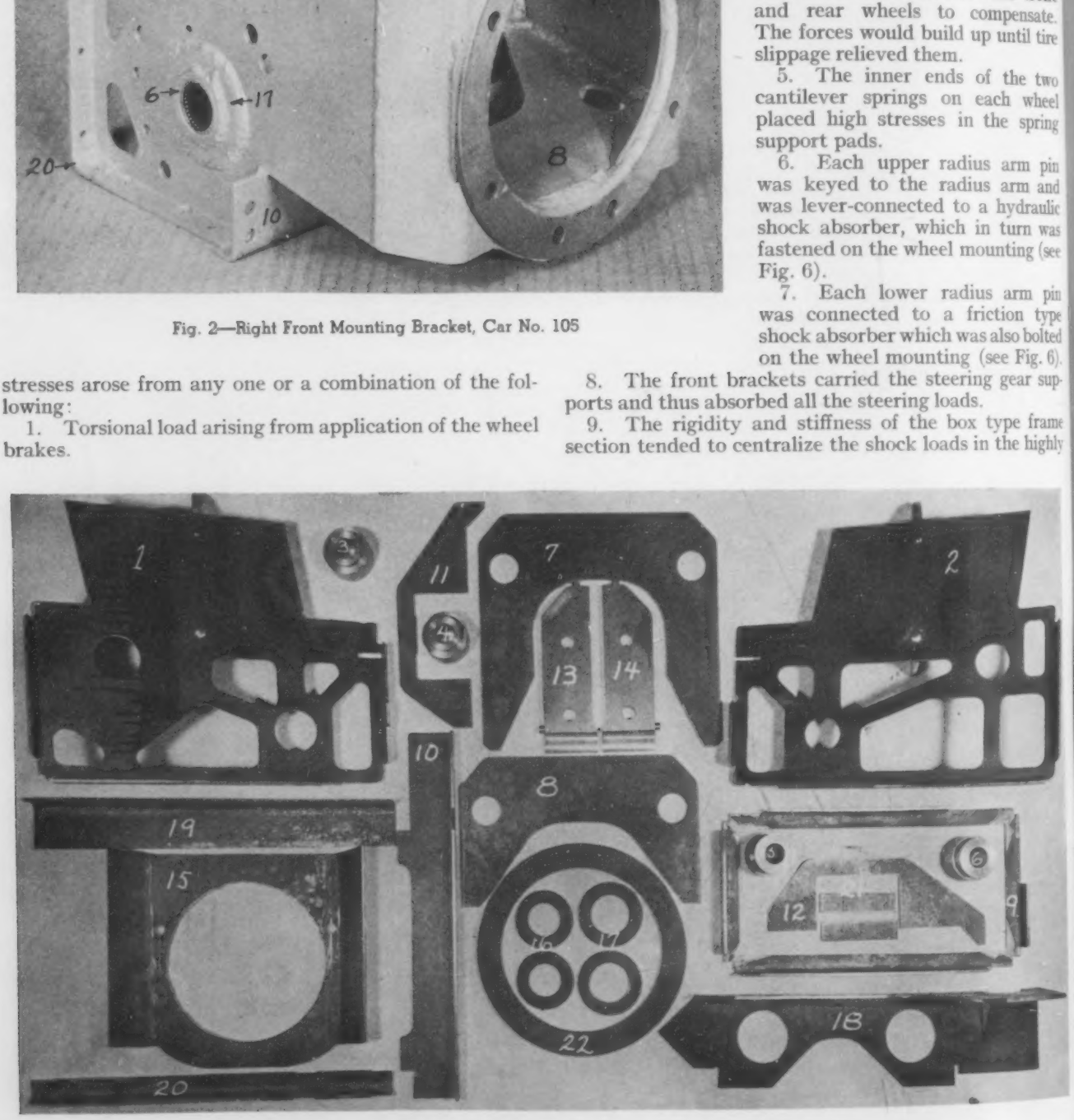

Fig. 3—Radius Arm Mounting Bracket Parts, 1941

stressed sections of the wheel mountings.

It was quite evident from the stress analysis of the possible combinations of the above loads that material of extremely high strength would be required if the weight was to be kept within reasonable limits. It was also apparent that the choice of fabrication lay between arc welding or cast construction if the piece were to adapt itself to mounting of the mechanical parts already made. The complicated nature of the wheel mounting required by the many fastenings for other parts, coupled with the low-weight requirement necessitated material thickness of not greater than $^1/_8$-in. for the most part, with thicker sections only allowed where extremely high stresses required.

Cast construction was abandoned in favor of arc-welded construction because of the following reasons:

1. The complicated nature of the bracket made possibility of securing reasonably sound castings improbable, if not impossible.
2. Experience with the steel castings used in the simple previous design had been partially unsatisfactory.
3. There was not enough time to experiment with steel-casting methods.
4. Strength tests on cast metal could not be made satisfactorily, without actual destruction of a casting. Tests on one casting would not insure that the strength of another similar casting would be satisfactory.
5. Only by use of arc-welded construction would it be possible to stress sections close to the safe calculated limits to keep the high-strength weight ratio required.
6. By use of arc welding, physical tests of sample weld specimens would give close criterion of safe working loads.
7. The cost of a pattern of such a complicated steel casting would exceed the arc-welded fabrication cost of the small number of wheel brackets required.
8. A high-strength alloy steel which could be satisfactorily arc welded and heat treated was available in S.A.E. X-4130.

Chromium molybdenum steel S.A.E. X-4130 was selected because of its excellent welding properties, high impact strength to tensile strength ratio, its receptiveness to heat treatment and its ready availability. Figure 3 shows the 25 separate pieces which were shaped from S.A.E. X-4130 sheet stock and bar stock to make up the wheel-mounting brackets. Most of the pieces were $^1/_8$ in. thick while some were made from $^3/_{16}$ in. thickness where required for strength. The spring support pads, parts 13 and 14, were made from $^3/_8$-in. thick bar and the radius arm bearing bosses, parts 3, 4, 5 and 6, were made from $1^1/_2$-in. diam. bar stock. All the sheet stock was used in the as-rolled condition. Bending and forming operations on the sheet stock were made at an elevated temperature, the parts to be formed being heated to a low red heat to prevent cracking at right angle bends, with excellent results.

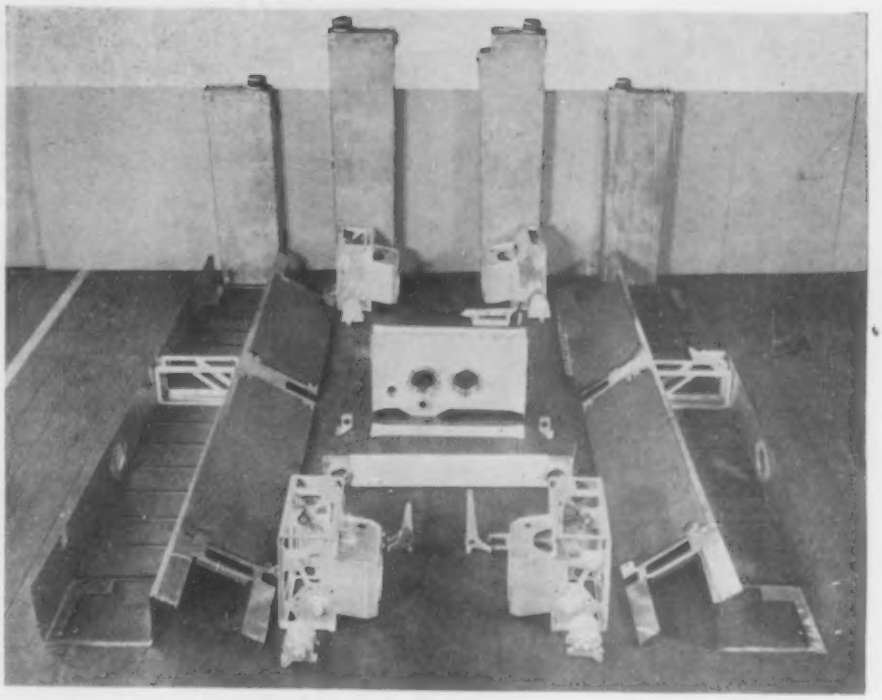

Fig. 4—Frame Parts, 1941 Model 183 Race Car, Feb. 10, 1941

Suitable Shielded Arc Electrodes in the $^1/_8$-in. diam. size were used in all the arc-welding operations. The rod was selected because of its smooth welding qualities and response to heat treatment like S.A.E. X-4130. Before welding was started, two standard A.S.T.M. welding samples were made from $^1/_8$- x 1-in. stock. These pieces were joined by 60° V-groove butt welds, the pieces first being preheated to 400 to 600° F., and allowed to air cool after welding. Following welding, these samples were machined to $^1/_2$ in. wide at the weld and the excess weld material removed. They were then pulled in a tensile machine with the following results:

	Tensile Strength	Elongation in 2 In.
Sample 1	90,880 psi.	2.5%
Sample 2	107,200 psi.	5.5%

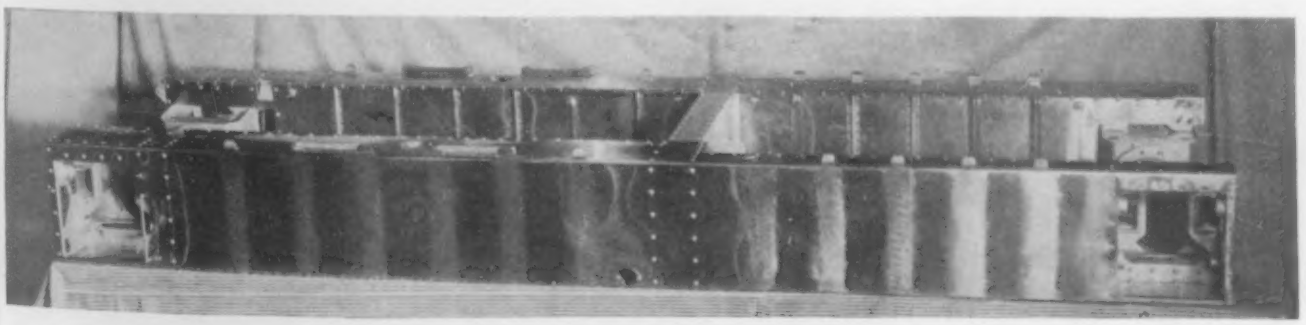

Fig. 5—Completed Frame, 1941 Model Race Car, Feb. 14, 1941

Fig. 6—Car No. 105, April 1941

These tensile strengths were considered satisfactory since tensiles of only 70,000 to 80,000 lb. would normally be expected in such welds without heat treatment subsequent to welding. The elongation was somewhat lower than desirable, but this would undoubtedly be improved by proper heat treatment after welding. Following these tests, it was decided to use V-groove welds only where high strength was required. Plane fillet welds were used where stresses were low. Single-pass welds were used throughout.

Very simple fixtures were used to hold the parts in place for welding. Two hollow spacer bars and two 1-in. threaded rods were used to hold the side plates, items 1 and 2, in position. The rods were run through the radius arm bearing bosses, items 3 and 5, and 4 and 6, and pulled up with the spacers between. This simple assembly was clamped to a surface plate as required throughout the assembly operations to insure proper alignment. Individual parts were held in place for welding by clamps as required. Locating pins were used to assemble the spring pads, items 13 and 14, as they had to be machined before assembly, and their location was quite critical.

The order of assembly and welding of the parts was as follows (please refer to Figs. 1, 2 and 3) (preheating to 400 to 600° F. was done before each weld was made):

1. Spring pads, items 13 and 14, were assembled on the side plates 1 and 2. The locating pins were peened over to assure proper location and a screw was used to hold the inner ends in place. These parts were not welded in place until later.

2. Assemble and weld reinforcing rings, items 16 to plate 1 and items 17 to plate 2.

3. Assemble the inner radius arm bearing bosses, items 3 and 4 in plate 1, weld inside to plate 1 and outside to reinforcing ring, item 16.

4. Assemble radius arm bearing bosses, items 5 and 6 in plate 2. Weld inside to plate 2 and outside to reinforcing ring, item 17.

5. Assemble spring pad support plates, items 11 and 12, and weld both sides to side plates, items 1 and 2.

6. Assemble side plates 1 and 2 with the spacer bars and rod bolts in position and clamp this assembly face downward on a surface plate for alignment.

7. Assemble reinforcing plates 7 and 8 and weld in position, both sides, to items 1, 2, 3, 4, 5, 6, 11 and 12.

8. Assemble back plate, item 15, and weld to side plates, items 1 and 2; then to reinforcing plates, items 7 and 8; then inside to spring pads, items 13 and 14. Complete welding of spring pads to side plates, items 1 and 2.

9. Assemble inside top angle plate, item 18, in position and weld to side plates, items 1 and 2, then to item 7, both sides.

10. Assemble lower inside angle plate, item 10, and weld to items 1 and 2, then to reinforcing plate, item 8.

11. Assemble upper outside angle plate, item 19, and weld to side plates, items 1 and 2.

12. Assemble lower outside angle plate, item 20, and weld to side plates, items 1 and 2.

13. Assemble steering support angle section, item 9, and weld to items 10, 18, 19 and 20.

14. Assemble spring pad support stiffener, items 21, and weld to items 11 and 12, 13, 14 and 7.

15. Assemble positioning ring, item 22, and weld to item 15.

After welding was completed, the assembly was heat treated. The spacer bars and rod bolts were left in position during the heat-treating operation to hold the assembly from distorting. The heat treatment consisted of normalizing at 1600 to 1650° F. and drawing at 1000 to 1100° F. to secure a hardness within 200 to 225 Brinell hardness number. Sandblasting to remove scale was the next step.

In order to determine the presence of cracks, holes or general porosity in the welds at the highly stressed parts, X-ray pictures were taken of the welds around the radius arm bearing bosses and the spring pads. These X-rays showed excellent welds.

All the eight brackets came through the above fabrication and heat treatment with negligible distortion, for the most part less than $^1/_{64}$ in. Only one or two brackets needed to be filed a small amount to be made to fit. The only machining required was a milling machine operation to face and bore the radius arm bearing bosses, a lathe operation to turn and face the positioning ring, item 22, and drilling of the bolt holes for assembly to the frame sections. Figures 4, 5 and 6 show clearly the position of finished wheel mounting brackets in the frame of the car.

Costs

In the building of the two racing cars, costs of construction was secondary to performance. In racing automobiles of this nature, the vital problem is to make all parts just strong enough to meet all the stresses and abuse to which they are subjected during a certain known period of time. These cars were built to last out the 500 miles of terrific punishment in the Indianapolis Memorial

Fig. 7—Rear View, 1941 Race Car

Day race. Elimination of all unnecessary weight was a vital necessity. Therefore, materials with the greatest strength weight ratio were used throughout. The materials and methods used in building the wheel brackets described above gave the utmost strength and lightness possible in meeting the very severe stress conditions. The success of this type of construction was adequately borne out by the absence of failures or trouble of any kind with these wheel brackets during preliminary testing or in actual racing.

As stated previously, cast steel construction was a possibility. Figure 8 shows one of the steel castings used in the first frame design which incorporated a channel section side rail. Comparison of the two pieces (Figs. 1 and 2 and Fig. 8) indicates the greater complexity of the shape of the new arc-welded bracket over the old cast steel design. Had the new brackets been cast, four separate patterns would have been needed. On the basis of the cost of the pattern for the old type bracket ($311), each of the four new patterns would have cost approximately $350 each or $1400 for patterns alone. Castings cost for the old type bracket was $6.00 each in lots of 24. This many would need to be purchased to be assured of getting eight reasonably sound castings. This cost, then, for castings for two cars would be

Patterns, 4 at $350.00	$1400.00
Castings, 24 at $6.00	144.00
Total	$1544.00

The cost of making eight arc-welded brackets was:

Material		
400 lb. S.A.E. X-4130, at 18¢./lb	$ 72.00	
16 lb. Electrode at 25¢/lb	4.00	
Handling charge, 10%	8.00	$ 84.00
Labor		
Fabrication of pieces		
8 units at 22 man-hours, ea. at $1.00 per hour	$176.00	
Welding		
8 units at 16 man-hours, welder at $1.00 per hour	128.00	
8 units at 16 man-hours, helper at $0.75 per hour	96.00	
Overhead charge, 40% on labor	160.00	560.00

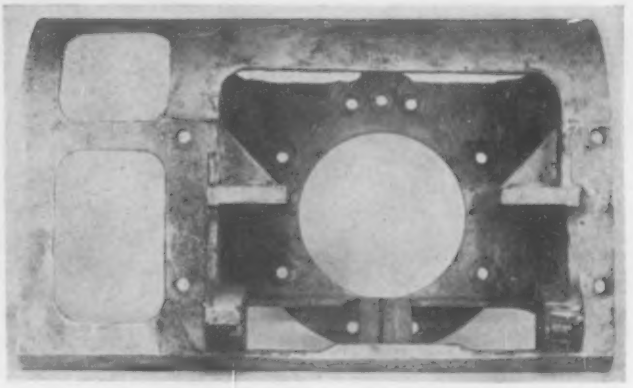

Fig. 8—Original Type Cast-Steel Bracket

Fixtures	
2 bolts and 2 spacer bars (labor and materials)	4.00
Power	
150 kw.-hr. at 2¢	3.00
TOTAL COST	$651.00

Heat treatment and sandblasting are not figured in, as practically identical treatment would be given to steel castings as to the arc-welded brackets.

The actual cost saving of arc-welded construction was, then, $1544 less $651 or $893 for the eight brackets. This savings in cost was only incidental to the more important factor of increased strength and safety of the arc-welded construction over the cast construction.

Were such a complicated piece to be made in quantity production, the pattern cost for a cast steel unit would be charged off to a considerable number of pieces which in turn would bring the unit price way down. However, to offset this apparent advantage would be both the very low cost of punch press fabrication of the pieces making up the welded unit and the economies of production line welding. It is believed that even in quantity production the cost advantage would still be in favor of the arc-welded construction.

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(*Continued on page 545*)

Adaptation of Welded Steel to the Paper Machine*

By R. S. Conabee†

Foreword

TO the welding fabricator, the paper machinery trade is a relatively uncharted territory. In order to invade this territory, the welding fabricator must make himself familiar with the problems confronting the papermaker and the paper-machine fabricator in order to functionally adapt his weldments.

The paper-machine tender learns his trade over a long period and is inclined to the viewpoint that the difference between good paper and poor paper lies entirely in his skill, and that the machine itself is secondary. I do not contest this. The situation, however, has hindered the progress of the machine parts in keeping with progress in other fields. An experienced papermaker said, at the recent meeting of the Technical Association of Pulp & Paper Manufacturers, that relatively little progress has been made in the science of making and drying paper in the last fifty years. The same can be said of the paper machine.

In this field as in others, there has been an ever-increasing demand from management for greater production. Existing paper machines have been speeded up by the adoption of more modern power plants and drives, and by increasing the efficiency or numbers of drying cylinders of the machines. The tendency in paper-machine manufacturers has been to wider spans and higher speeds. With the increase in span and speed, the conventional machine structures, especially in regard to materials, are beginning to show design limitations. Manufacturers are beginning to turn to steel in order to satisfy the demand for stiffness and strength required in the new machine structures. Welded steel, incorporating large-sized predictable structures, with a high strength to weight ratio, furnishes the best answer to these problems.

Lukenweld Inc., a welding fabricator, has been for some time producing steel dryers that enabled machines to step up their drying capacity as machine speeds were increased. Recently, having with us a paper-machinery and papermaking expert, we obtained a far-sighted customer willing to take a chance on a new design and a new material in an all-welded steel paper machine.

It is not intended to go into the principles of making or welding the paper machine parts—enough material can be found in any handbook or drawn from the fabricators' experience for that. At the same time, digressions made into the papermaking processes may sound like McGuffey's *First Reader* to the paper expert. The principal intention is to demonstrate to the welding fabricator that welded steel is admirably suited to the making of paper machinery.

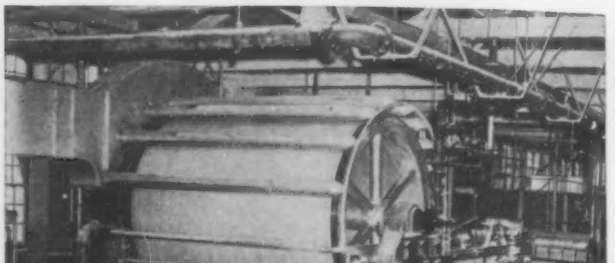


Fig. 1—General View of the Machine

The Machine

While the primary intention of this paper is to present the advantages of welded steel in the papermaking field, it will be helpful to go into the actual operations in the making and drying of paper on this installation in order to understand the job assigned to the welded parts. The operations noted in the subsequent paragraph may be traced through the machine by following the lettered symbols on the assembly print (Fig. 2).

Briefly, the machine is of the fourdrinier type in which the paper stock, an extremely dilute suspension of pulp fibers in water, is directed, *A*, onto a moving fine mesh wire screen, *B*, most of the water passing through the screen, depositing a thin film of wet pulp on its surface. The wire passes over suction boxes, *C*, which drag out part of the moisture as it passes to the couch rolls, *D*, where a steam drum on the upper side of a felt picks up the film on the felt surface. Another felt strip is passed up to the exposed side of the film and the resulting sandwich squeezed by a press roll, *E*, removing more of the moisture. The film is then plastered up against the first Yankee dryer by a rubber-covered roll, *F*, where it remains by itself, the felts returning over a series of rolls where they are sprayed to remove any

* Third Prize Award paper, Section K, Industrial Machinery, 1940–42 Industrial Progress Award Program sponsored by The James F. Lincoln Arc Welding Foundation, Cleveland, O. The award papers showed a possible saving of $1,825,000,000, including 7,000,000 tons of steel and 153,000,000 man-hours of labor available by application of arc welding.

† Engineer, Lukenweld, Inc., Coatesville, Pa.

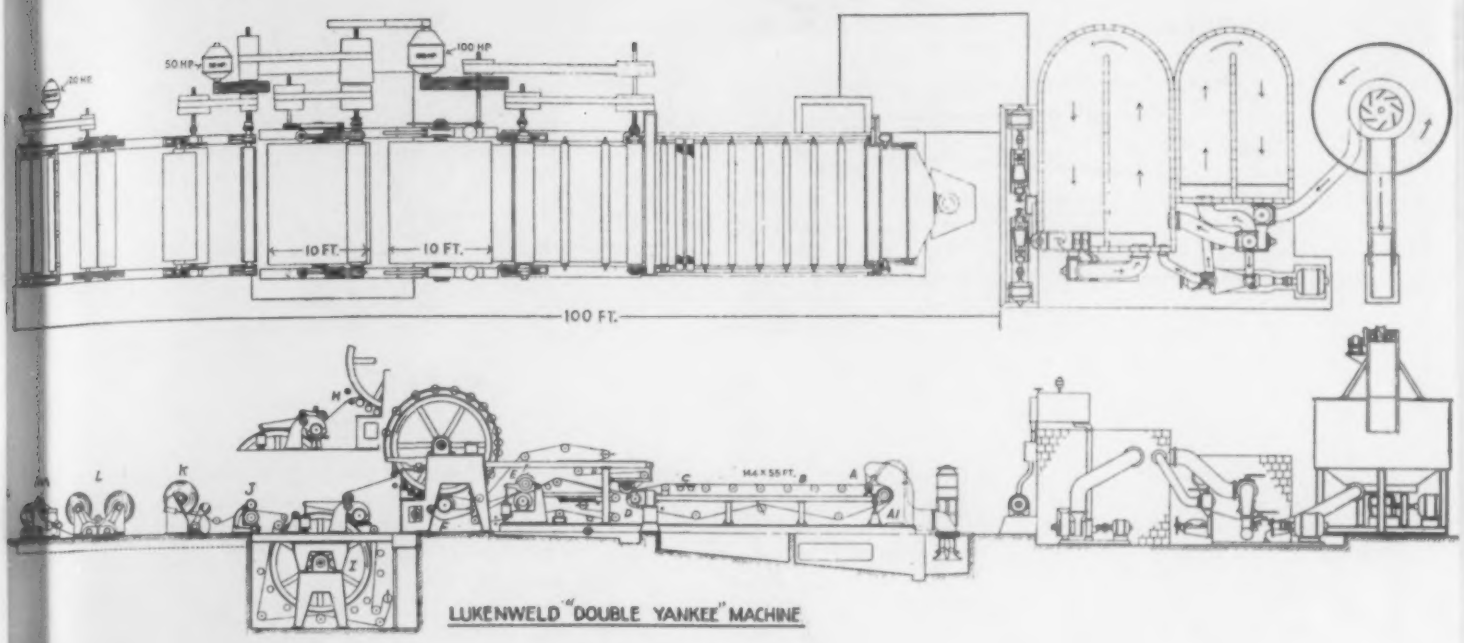


Fig. 2

fuzz remaining, removing the excess moisture by suction, *G*.

The paper film on the drum is rapidly dried and scraped off at *H* by a bronze blade, a process called "creping." The paper is now led over the secondary dryer *I* on its reverse side where the drying process is completed. On the secondary dryer, the paper is held into close contact by means of a tight felt.

The paper is now led through the calender *J*, an "ironing" operation on a steam drum, thence to the reel *K* and wound on a spool. Processes *L* and *M* illustrate unwinding two rolls into one sheet passing over a slitter roll, where it is score-cut into desired widths, and rewound onto reels.

The machine (Fig. 1) is designed to produce a wide range of light papers, among which are toilet tissue, napkin stock, facial tissue, light-waxing stock, light M. G. papers, etc.

Paper machinery manufacturers will note that the machine is quite compact. Many modern machines producing equivalent grades of paper occupy from two to three times the space of this machine, and have a proportionate increase in the number of parts, drying drums especially, required.

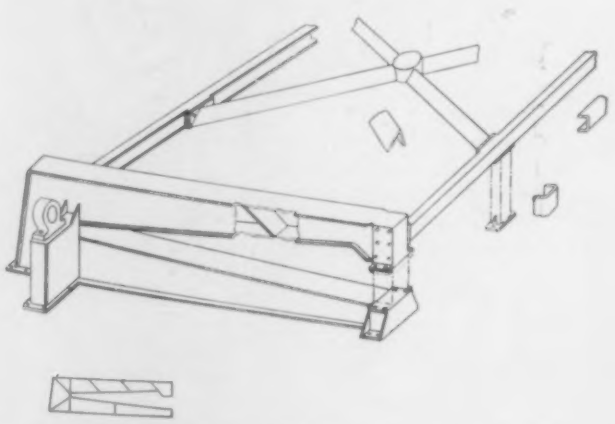


Fig. 3—Sketch of the Couch Roll End of the Fourdrinier Frame

In presenting the adaptation of welded steel to the welding fraternity, it will be necessary to go into these processes more thoroughly in order to demonstrate the functional design principles involved.

The Fourdrinier Section

The first operation of the fourdrinier, that of directing a stream of paper stock onto the moving wire, is one of the most delicate and most important in the whole papermaking process. It is essential that this stream be of constant cross section, velocity and consistency throughout its entire width in order to insure a sheet of uniform quality and caliper. This is evident from the fact that each fiber is compressed and dried into paper in its relative position as deposited on the wire.

The flow spreader designed for this job was constructed in three sections plus two end supports in order

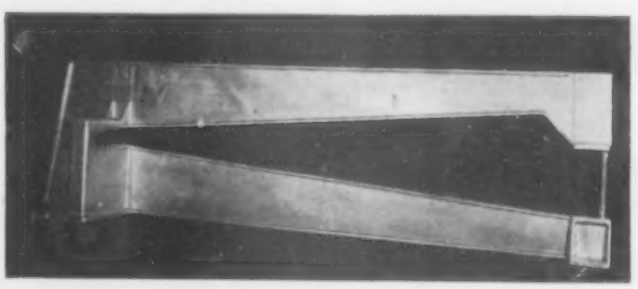


Fig. 4—Couch Roll Support

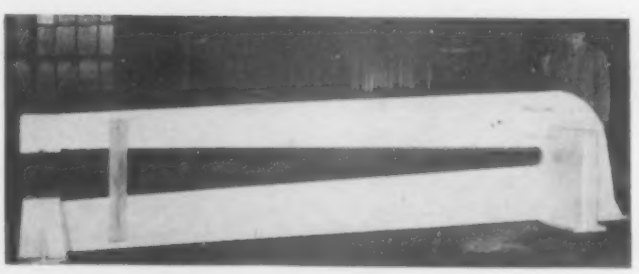


Fig. 5—Breast Roll Support

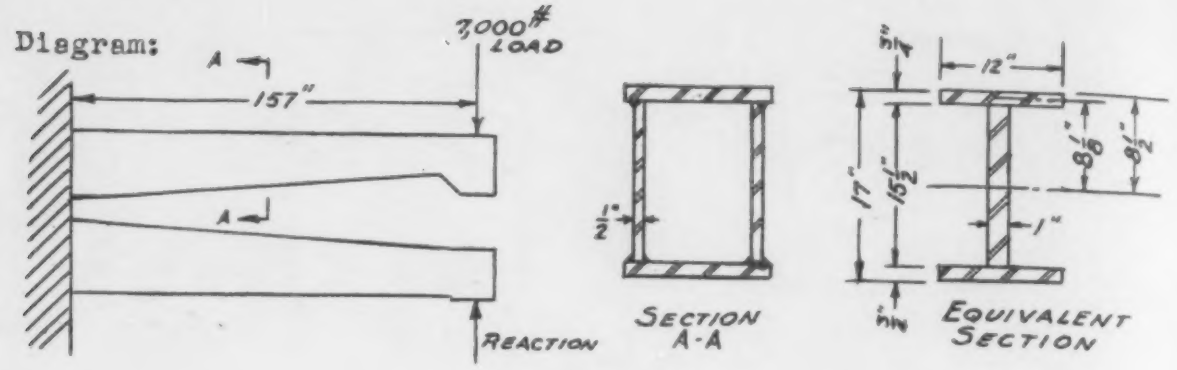


Fig. 6

to facilitate machining. It would be quite feasible to fabricate the structure as a unit, but the machining problems would be prohibitive. Prior to machining, the three flow sections were hot-dip galvanized to prevent corrosion.

The stock is pumped into a large compartment which slows down the flow, permitting the stock to spread and develop an even pressure head across the entire width of the chest, and breaking up any tendency toward "streaking." The velocity is built up again as the flow rises through a passage that is gradually restricted in the direction of flow. At the height of its rise, the direction of the flow is changed abruptly and directed downward onto the wire. The resulting centrifuge develops a turbulence which effectively distributes the paper fibers, and insures complete and uniform filling of the passage as the stream is directed downward onto the wire.

The stock passage is entirely unrestricted through its entire length from pump to wire. This condition, while ideal from the flow standpoint, presents structural problems that are best met by a stiff-welded steel construction. Pressure variation, or surges, tend to belly the nozzle outward, which tendency is greatest in the center due to restraint at the ends, and since they may not be tied together, must be supported independently. To this end, 12-in. steel pipe is used as a beam over the upper lip and below the lower, and connected to their respective lips by ribs.

Thus they support the plates which form the nozzle and offer the most effective resistance to the bellying action of the nozzle, since deflection in this direction must distort the tube torsionally. The efficacy of this construction was demonstrated by producing a glass-like film of pulp on the wire without the conventional screw adjustment on the lip.

The pipes are welded at their ends to a connecting plate which forms the side of the nozzle passage and furnishes a bolting flange to the end supports (note *A1* on the assembly), which hold the nozzle assembly as a cantilever out over the wire. These supports are simply and inexpensively produced as a single gas-cut plate with pads welded to the feet to serve as bolting flanges.

The moving, bronze, wire screen upon which the paper film is formed, is supported at the ends by rolls, on the top by intermediate table rolls and tightened underneath by a stretch roll arrangement.

The rails which support the table rolls were constructed of bent channel sections which furnish a concealed bolting surface, and braced laterally by an X-frame as shown by Fig. 3. Note the inverted V-section of the cross-bracing member which allow smooth drainage from the wire to the collector pans hung from the framing. This is important from the consideration that any shelving or projections allow the pulp fibers to collect and drop off in concentrations, resulting in irregular consistencies when recirculated.

It would be impossible here to duplicate these sections and span in castings; and a riveted structure would involve surface irregularities resulting in the undesirable pulp concentrations noted previously.

The provision made for changing the wire is unique on the welded steel framing. Ordinarily, the rolls carrying the wire are moved out of their framing by a complicated auxiliary equipment and held free while the wire is changed. This entails a considerable amount of time as well as providing and maintaining auxiliaries.

In the welded steel framing, the table roll frame is supported between two rectangular open structures, the upper beam of each supporting on its outboard side the end wire rolls, as shown on the machine assembly. Note from the assembly that the wire passes through

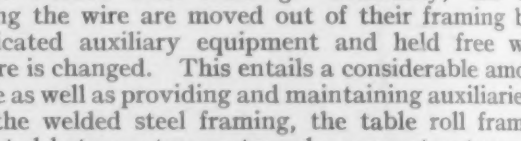


Fig. 7

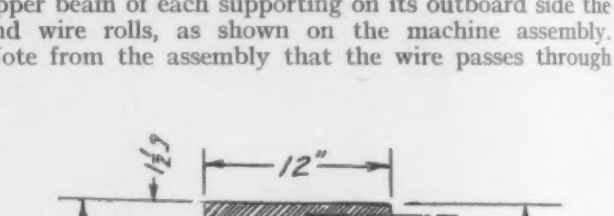


Fig. 8—Section Through Steel Couch Roll Support and the Section Required in CI for Equivalent Stiffness

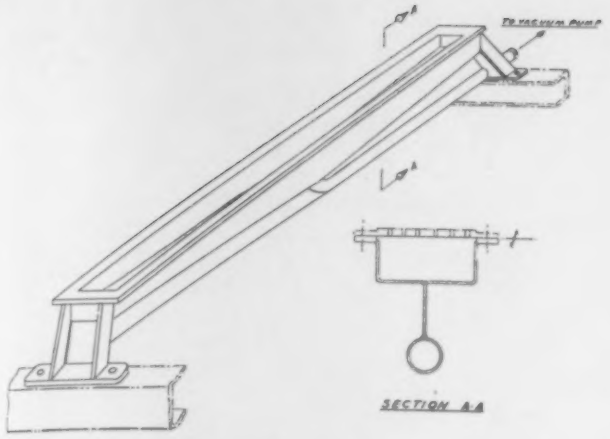


Fig. 9—Suction Box

the open center of the supports, totally enclosing the upper beams within the wire.

When operating, the front rail supports and "kick out blocks," noted in phantom on Fig. 3, are in place, forming a closed and stable frame. When it is necessary to change the fourdrinier wire, these pieces are removed, allowing the wire to be slipped off and replaced over the entire roll assembly without obstruction.

This feature presents design complications that were effectively met by welded steel. It will be noted that one end of the couch roll, table rolls and rails, suction boxes, bearings and miscellaneous machine parts are supported by what amounts to an open C-frame when the front blocks are removed. The total reaction amounts to approximately 9000 lb., distributed 7000 lb. to the couch end and 2000 lb. to the breast roll end. The end reaction of the couch roll, being outboard of the support, imposes an additional torsional moment. Neglecting torsion, this structure can be compared to a $3^1/_2$ ton C-frame with an open throat of 155 in.

To provide this support, the frame illustrated in Fig. 4 was developed, incorporating a box section because of the torsional load. The side plates were gas cut from sheared rectangular plates; the top and bottom flanges and the throat members were universal mill-rolled flats.

The two flanges and the internal ribs were designed to constitute a rigid truss, as shown in the lower left-hand corner of Fig. 3, and further reinforced by the side plates as shear members. Stresses were kept low, approximately 4500 psi., in order to have little deflection.

The flat plate frame shown in Fig. 5 was developed to perform a similar function on the breast roll end of the frame. A flat plate is suitable there since the torsional moment is negligible and the total reaction at this end comparatively light. The economy of such a structure using a single gas-cut plate as the principle member is apparent.

Design Comparison of Cast Iron and Steel in the Couch Roll Support (Fig. 4).—The following computations for the welded-steel couch support have been simplified for a quick comparison with a cast-iron frame having the same stiffness characteristics within the same space limitations.

The deflection is based here on the average beam section loaded as a cantilever, neglecting deflection in the throat section and restraint of the rear hold-down bolts (Fig. 6).

Then:

I (each section)

$$Ay^2 = 2(12 \times {}^3/_4)\ (8.125)^2 = 1188$$
$$\text{Plus } bh^3/_{12} = (15^1/_2)^3/12 \quad = \underline{\ 310}$$
$$1498 \text{ in.}^4$$

And deflection of both cantilevers $= 2FL^3/3EI$

$$\frac{2(7000)\ (157)^3}{3(30^6)(1498)} = {}^{13}/_{32}'' \text{ approx.}$$

The actual deflection was less than this as might be expected from the use of the tapered beam section.

To continue with the comparison, if the frame were to be made in cast iron, neglecting weight as previously, the moment of inertia required would be inversely proportional to the elastic modulus involved:

$$I = 30^6/15^6 \times 1498 = 2996''^4$$

Because of the wire clearances, top and bottom, the same space limits must be imposed. Then, letting ga. of flange plate equal $1^1/_2$ ga. of side plate as in the steel section, the moment of inertia of the required section Fig. 7 will be as follows:

$$\begin{aligned} I \text{ (flanges)} &= 2(12 \times 1^1/_2\, g)\ (8^1/_2 - 0.75g)^2 \\ &= 36g(72.25 - 12.75g + 0.5625g^2) \\ &= 2600g - 459g^2 + 20.25g^3 \\ I \text{ (webs)} &= bh^3/12 = 2g(17 - 3g)^3/12 \\ &= {}^1/_6(4920g - 2601g^2 + 459g^3 - 27g^4) \\ &= 820g - 433g^2 + 76.5g^3 - 4.5g^4 \end{aligned}$$

Adding the two:

$$I = 3420g - 892g^2 + 96.75g^3 - 4.5g^4 = 2996''^4$$

And solving the equation for g, we find that $g = 1.20$ in.

The resulting section will have webs $1^3/_{16}$ in. thick, flanges $1^1/_2 \times 1^3/_{16}$ in. or $1^{13}/_{16}$ in. thick, and will result in the same theoretical deflection as the steel section (Fig. 8) with $g = {}^1/_2$ in.

Suction Box

Suction boxes which remove a portion of the free water from the moving pulp film are mounted on the fourdrinier rails. As the wire is drawn over the suction box cover, it encounters a series of holes through which water is forced when a vacuum is produced inside the box. The suction box must be quite rigid in order to support this cover in a true plane, since any tendency toward sagging will cause excessive wear of the wire on the high points and poor contacts on the low portions, resulting in a lowered efficiency and a corresponding wet streak in the paper.

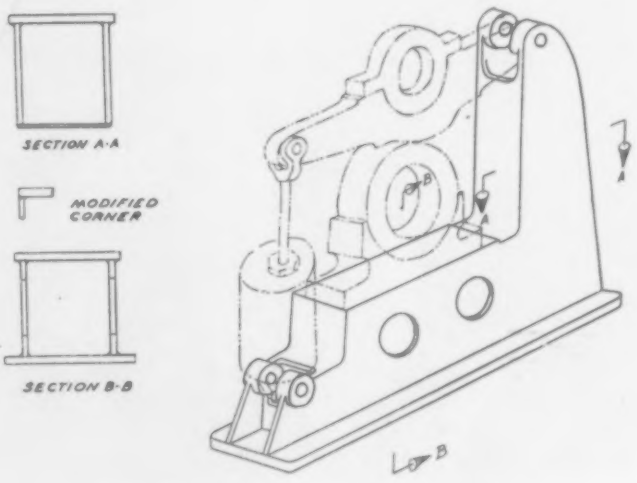


Fig. 10—Press Roll Frame Arrangement

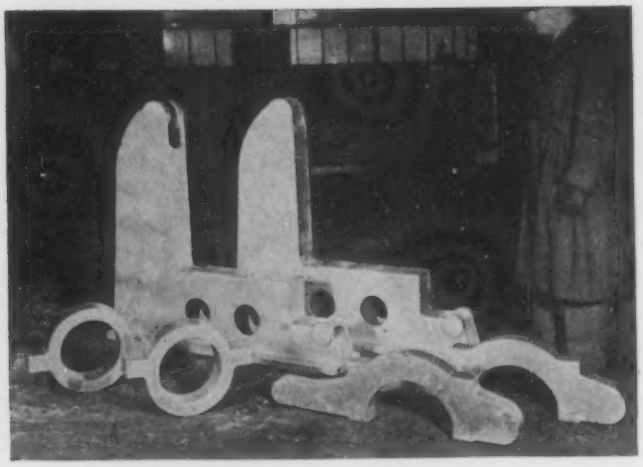


Fig. 11—Press Roll Frame Parts

In the usual method, the suction box is supported by an independent beam constructed of rolled sections, riveted sheet brass, cast iron, or wood, upon which the suction box of wood or brass is placed.

In the welded design, the suction box is built integral with the beam section and contributes to the stiffness of the structure. The box proper, consisting of a bent channel section together with the bolting flanges for the suction box cover, forms the upper flange of a beam. Note in Fig. 9 that the bent channel has been cut and trimmed so that the section is deeper in the center than at the ends, in order that the box will drain properly. To this channel is welded a web with a pipe at the bottom which serves as the lower flange, as well as to provide a means of exhausting the box and withdrawing water from its center. Thus, none of the structure is parasitic, each part contributing to the stiffness of the structure as well as its function.

As a protection against corrosion, the suction boxes were metal sprayed with bronze before installation.

Fig. 12—Primary Dryer Stands

Standard Section

At this point in the design of framing for the machine, a section was chosen as a standard that would be most satisfactory for the machine. This at first seems to be a minor point, but when it is understood that the section chosen must be used throughout in order that the machine will be uniform and pleasing in appearance, that it must be adaptable from other design considerations and that it must be capable of economic fabrication, then the selection assumes major proportions.

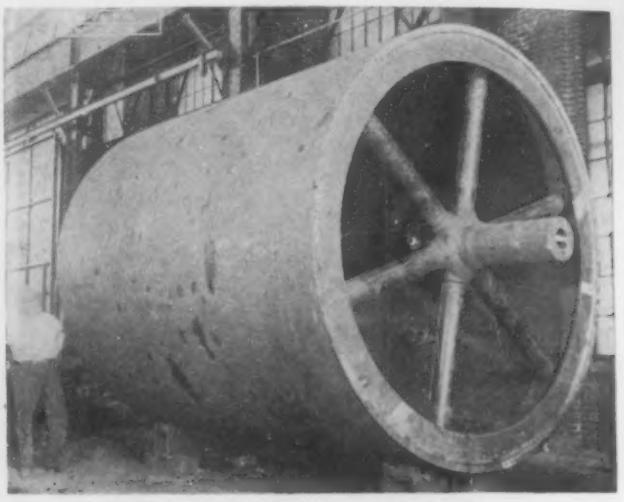


Fig. 13—Lukenweld "Yankee" Dryer

The box girder section chosen, Section *AA* of Fig. 10, is the most desirable for the following reasons:

1. The flat top plate can be used for mounting bearings, brackets and other machine elements conveniently, on the center line of the section.
2. The stiffness can be varied over a wide range to suit design considerations while preserving the same outward appearance, by web and flange gage variation, number and strength of web stiffeners and varying depths of section.
3. The interior of the section can be conveniently used to house moving mechanism as noted subsequently, and to conceal piping and wiring.
4. The members, including the webs, are accessible for welding by leaving the bottom or cover plate off until last.
5. The corner weld to the cover plate can be touched up with a hand grinder to produce the rounded corners desirable for appearance.
6. The bottom plate can be made heavy and extended at the sides to form a mounting surface and bolting flange as shown in Section *BB*.
7. The section matched that of the couch frame already discussed, this frame being practically dictated by design limitations.
8. The section, repeated in a number of frames, is pleasing in appearance. This item, incidentally, is placed last by the engineer, but first by the prospective customer.

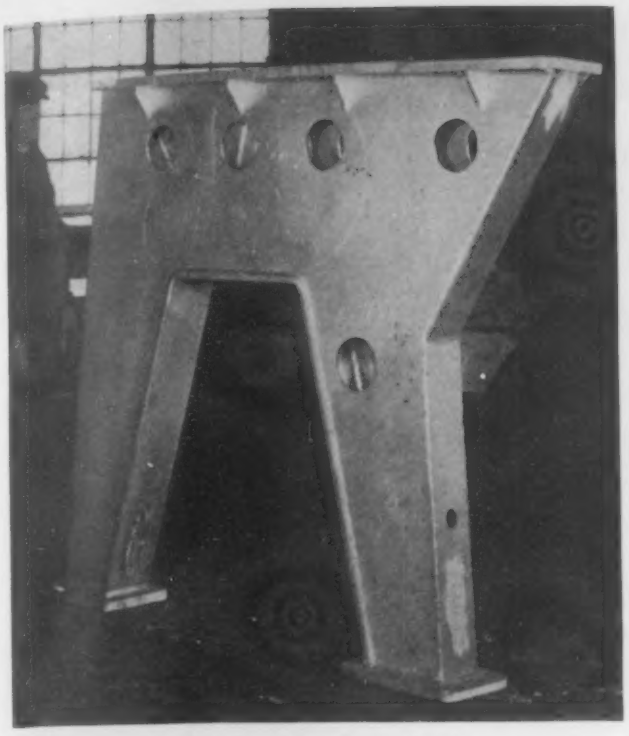


Fig. 14—Secondary Dryer Stands

Framing

The press frame is a good example of the adaptation of the standard Section, shown in Fig. 10. The base portion is built as Section *BB* and the upright as *AA*, both with the modified corner indicated. The base forms a sturdy support for a heavy chilled iron roll and the upright webs are extended to hold heavy plate rings which form the clevis for the pin of the upper press roll mounting arm shown in phantom in Fig. 10. This arm, incidentally, is gas cut from a single plate and represents a considerable saving in time and money over the usual casting procedure. The gas-cut plate will cost less than the pattern required.

One of the most important functions of the framework is the proper support of the two drying cylinders. The problem here is to support a drying cylinder, pictured in Fig. 13, the press roll, creping mechanism and miscellaneous other equipment such as bearings, air cylinders, totaling no small weight in themselves. The framework must also form a closed system to carry the reaction of the press roll which was designed to produce a force of 250 lb. per linear inch—a total force of 36,000 lb. The whole mechanism to be supported rigidly to hold driving vibrations to a minimum in order to produce a uniform sheet of creped paper.

To perform these functions, the frame shown in Fig. 12 was developed, the top surface supporting the main bearing and the actuating cylinder for the press roll. Welded into the webs and lower flange of the leg member are heavy bosses for the pin of the press roll arm. The shelf in front forms a rigid support for the creping and cleaning "doctors" for the dryer. The wide span of the bottom supports provides a good footing for the dryer support, the frame being widened out to include the press mechanism and to provide lateral stiffness and mass to absorb driving vibrations.

The web and flange structure alone forms a truss-like framework designed as such to effectively transmit the load to the foot plates, the whole then stiffened by the addition of side plates.

The dryer supported by these frames might be said to be the heart of the machine. The pulp film, having been made by the Fourdinier and prepared by squeezing a portion of the free water from it by the press section, is still a moist film without strength. It is only when the water is properly driven from this film leaving the interlocking fibers that paper is produced.

Note the statement, "properly driven." This entails a whole study in itself, and concerns many variables such as type and weight of paper, machine speed, etc., but let it be said here that one of the principle factors controlling the porosity in paper is the rate at which steam is formed and pushed through the fibers of the pulp film. It is immediately apparent, therefore, that an even surface temperature must be maintained on the surface of the dryer over its entire width and circumference.

Internal temperature can be controlled accurately by thermostatic devices, such as is done on this machine, but the production of a uniform temperature on the dryer surface is a mechanical function of dryer design and construction. Since the rate of heat transfer is inversely proportional to the mass of the material, according to Fourier's law, it follows that the prime variable is the uniformity of shell gage and density.

The large diameter dryer, commonly called a "Yankee" in the trade, together with the rubber-covered press roll, forms a second press section. This differs from the first press in that the wet pulp is pressed tightly to a hot polished steel surface, giving up 6 to 8% of its moisture content (approximately 20% of the total water removed) in so doing—and at the same time assuming a smooth and compact finish. Since the finish on the paper is produced by that of the dryer, a superior finish must be produced on the dryer in order to have an equivalent finish on the paper. This pressing action requires a force of approximately 250 lb. per linear inch, which force must be reacted by the shell of the dryer.

The design of the dryer shell, then, boils down to this: It must be uniform in gage and positively non-porous, since any porosity is in effect a gage variation that affects heat transfer; and it must be clean and dense enough

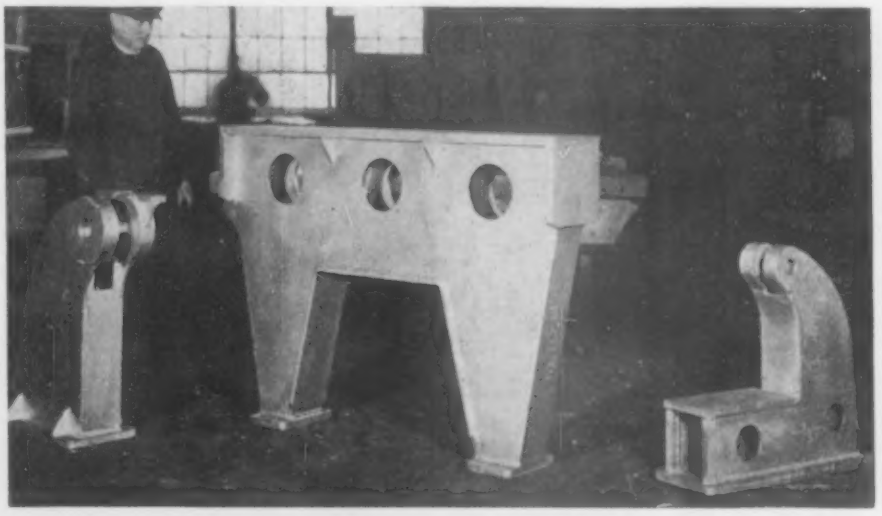


Fig. 15—Miscellaneous Rough Weldments

that a high polish can be applied to its surface by a grinding and lapping process.

Because of the inverse ratio between the rate of heat transfer and the plate thickness, it follows that the shell should be as thin as possible for the greatest drying capacity. It must be stiff enough, however, to withstand the concentrated linear load induced by the press roll and keep local deflection to a minimum. In this particular machine, it was determined that a gage of $1^1/_4$ in. was the most satisfactory for all conditions. Dryers operating under lesser press loads could have correspondingly thinner shells which would allow greater drying rates.

Steel plates for the dryers on this machine were rolled from selected ingots poured from special heats of a high-quality particularly clean steel. The plates were formed on bending rolls to close diametral tolerances, and the planed beveled edges were welded by a process that matched the hardness of the weld to that of the plate, the welds being X-rayed as an assurance that no porosity here would affect heat transfer.

This shell was welded onto an inner shell to which it connects by machined end rings to preserve its concentricity. These end supports are the only connection to the outer shell, hence there is nothing in the area on which the paper is dried which would be, in effect, a gage variation and would cause a corresponding temperature drop on the dryer surface. A degree of flexibility is provided by the arrangement that allows the dryer to accurately align itself with the press roll.

An annular space is provided between the inner and outer shells into which the steam is led. Here it condenses, liberating its heat units through the shell to the wet pulp.

The average drying cylinder is nothing much more than a hollow drum in which steam cannot condense efficiently, or rather, rapidly enough for efficient drying. Steam carries with it a certain amount of inert gasses which build up in the hollow interior producing an insulating blanket unless enough live steam is "bled through" the dryer to drag the entrapped gasses with it. This air-bound effect is much more pronounced in the large diameter dryers as might be expected since the volume varies with the square of the diameter.

In the annular space between the two shells of the welded steel dryer, steam condenses efficiently since it is impossible for a large band of gasses to form. In addition to this, two removal systems are provided to continually draw off the condensate and air, one functioning when the dryer operates below critical with the condensate collecting at the bottom, the other above critical as the condensate is slung around the dryer forming a band about its inner surface.

It has been customary to allow a considerable crown in a rubber-covered press roll in order to compensate for unequal expansion rates in the usual dryer between the center and the ends, because of the solid end construction.

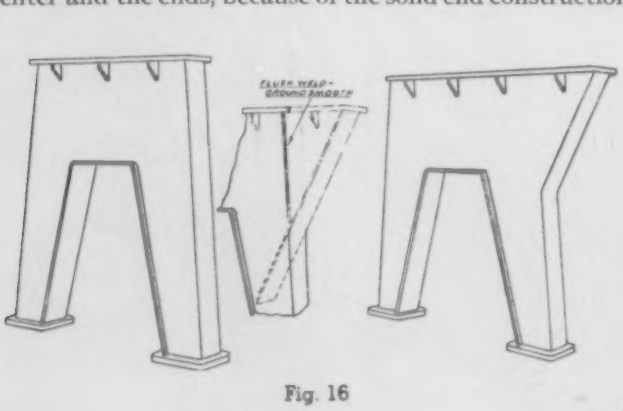


Fig. 16

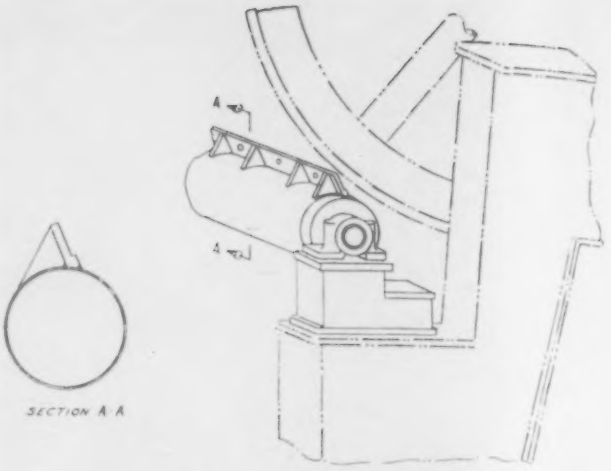


Fig. 17—Doctor Support Arrangement

Calculations on a 12-ft. diam. dryer show that this difference in expansion causes the face to be concave 0.025 in. which necessitates a crown of 0.050 in. in the press roll for this reason only. Abnormal wearing conditions resulting from the rubber being crowded sidewise make it necessary to regrind frequently.

The steel dryer in Fig. 13, designed for this machine, shown in the rough, incorporates tubular spokes which attach to the comparatively flexible inner shell. Any inequality of expansion in heating up, etc., is compensated by flexure in this member, allowing the outer shell to maintain its press roll alignment.

An inspection of the photograph will disclose that welding is the only feasible means of producing this fabrication. A casting in this form is entirely out of the question; and to build it up of smaller components introduces prohibitive machining and alignment problems.

It is in comparison with cast iron dryers that welded steel design shows its greatest superiority in the paper machinery field. The same physical laws apply to the cast-iron dryer . . . density, quality of finish and stiffness directly affect the quality of the paper, and the shell thickness and method of condensate removal have a direct influence on the effective drying rate of the cylinder.

First of all, in order to design for a certain required stiffness, the lower elastic modulus of cast iron results in a thicker shell than is required by a steel dryer. The average cast-iron shell is between $2^1/_2$ and 3 in. thick, which is determined not only from stiffness considerations, but also by the Code for Unfired Pressure Vessels with limitations in steam pressure according to the various state laws.

These factors tending to increase the shell gage create a vicious circle from the standpoint of efficient operation. All other things being equal, a greater temperature gradient must be supplied to drive the same amount of heat units through a thick shell than a thin one, and conversely, a 1-in. shell can transmit twice the heat units than is possible with a 2-in. shell.

It is this premise which accounts for the compactness of the steel machine. With the attending higher rate of evaporation on the surface of the thinner shelled steel dryers it is possible to do the same amount of drying with fewer cylinders than can be done on the regular paper machine. For a given production, a space and materials economy can be effected—for a given machine, production can be stepped up because of increased drying capacity with steel dryers replacing the cast iron.

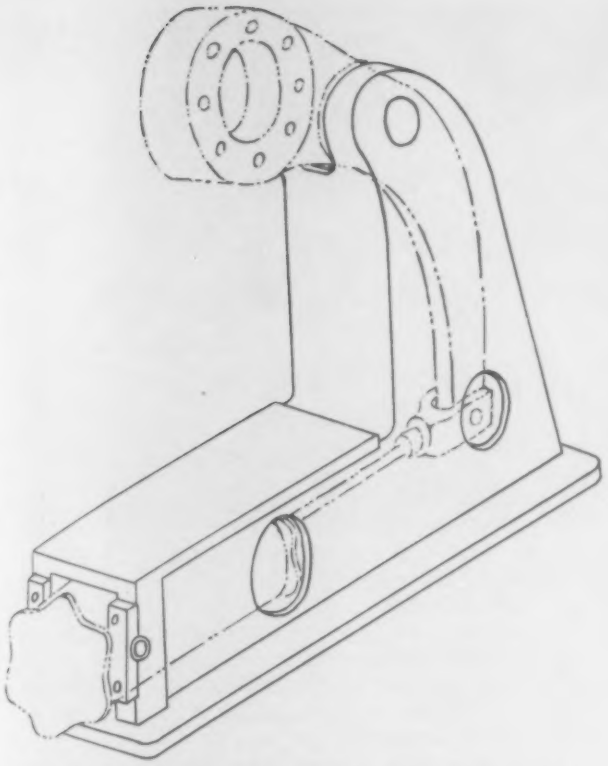


Fig. 18—Calender Frame and Loading Arrangement

There is a distinct difference in the quality of surface between a steel and a cast-iron dryer. The steel, having been rolled to gage from an ingot, has undergone hot work which reduces and refines the granular structure and produces a material capable of taking a high polish. Cast iron, however, is a mechanical composition of graphite particles in iron, and as such is a basically porous structure. No amount of polishing will overcome the fact that the surface is a composite material instead of a uniform chemical composition.

Because of the greater mass of the cast-iron dryer, more power must be supplied to accelerate and drive them; and bearings, frames and other machine elements must have proportionally greater capacity.

The secondary dryer was mounted in a pit in order that the opposite side of the paper could be presented to the dryer surface without interfering with the straight-through flow of the paper and at the same time allow a maximum arc of contact. The greatest percentage of drying has taken place on the first dryer; the secondary dryer completes the drying process and improves the surface of the paper that was not previously in contact with the dryer. The secondary dryer is essentially the same as the first and needs no further discussion.

The framing, however, varied since no shelf was provided for creping as on the first dryer stand. Secondary pedestals that form a continuation of the mounting rails over the dryer bearing were fabricated as separate units to facilitate erection. These two stands and pedestals shown in the rough in Figs. 14 and 15 follow the same design form as the primary dryer pedestals, consisting essentially of the standard section with interior ribs so placed as to stiffen the structure, especially at the inner flange corners, the points of greatest stress.

Flexibility of the Welding Process

During the fabrication of the paper machine weldments, a situation arose that demonstrates the flexibility of the welding process that was actually taken into consideration in the design of the machine. At its inception, the time element did not permit making a complete set of working drawings showing each part of the machine in its exact relation to the others, according to the best practice. It was necessary to begin with a rough draft of the machine showing the principle machine elements only in place, such as dryers, press rolls, fourdrinier rolls, felt rolls, calenders, reels, etc., and delineating their respective center lines and clearances.

With this arrangement drawing, the subcontractors furnishing machine elements and the driving mechanism, as well as our shop in its design of the welded component proceeded concurrently toward the production of the whole. This was done only to meet delivery schedules which would otherwise have been impossible. The weldments were ordered into the steel immediately as designed in order to expedite this schedule. At all times the closest cooperation was maintained between the separate fabricators, but it was foreseen that some interference might be encountered which could be circumvented by altering existing weldments to suit. This faculty of the welding process, then, was utilized to save time.

After the stands had been fabricated, but before machining, it was found that the top surface of one secondary dryer stand had to be extended to provide outboard support for a pinion bearing, the two stands having previously been similar.

Figure 16 shows the process of altering the stand. A part of the end plate and one stiffening rib were gas cut away, a new rib extending to the extremity of the outboard support was provided and new side plates and top plate extensions were cut, welded into place and the welds ground smooth. The resulting structure showed no signs of the change and was apparently designed as such originally.

This, to the welding fabricator is nothing new—it is, in fact, "old stuff." It is merely included to serve as an example of the flexibility of the process in permitting design changes economically, even subsequent to fabrication. The designer need not be held down to having every part correct to the most minute detail before ordering any of the components.

With particular reference to the dryer stands, it is questionable whether these parts could be produced by castings in the form that they are shown here; but even when redesigned to suit foundry practice, it is apparent that the patterns would be quite bulky and complicated, and would, in themselves, represent a considerable outlay. No two stands are alike, so that one could not serve for all.

If one frame or series of frames is made to serve for all, then the functional design of the machine must suffer.

It is also evident that a major design change after the casting is poured involves scrapping the casting, altering the pattern and producing a new casting. It is as an old foundryman said when asked to make a change in a casting: "When you pour the mold, brother, there it is!"

The only alternative in this case would be to cast a new bracket separately and bolt it in place. As well as being makeshift in appearance, this would involve alignment problems at assembly.

Creping Supports

Certain grades of paper must be creped, or removed from the first dryer by a scraping action. The dried film on the paper drum encounters a sharp blade which causes the paper fibers to crumble upon themselves, a

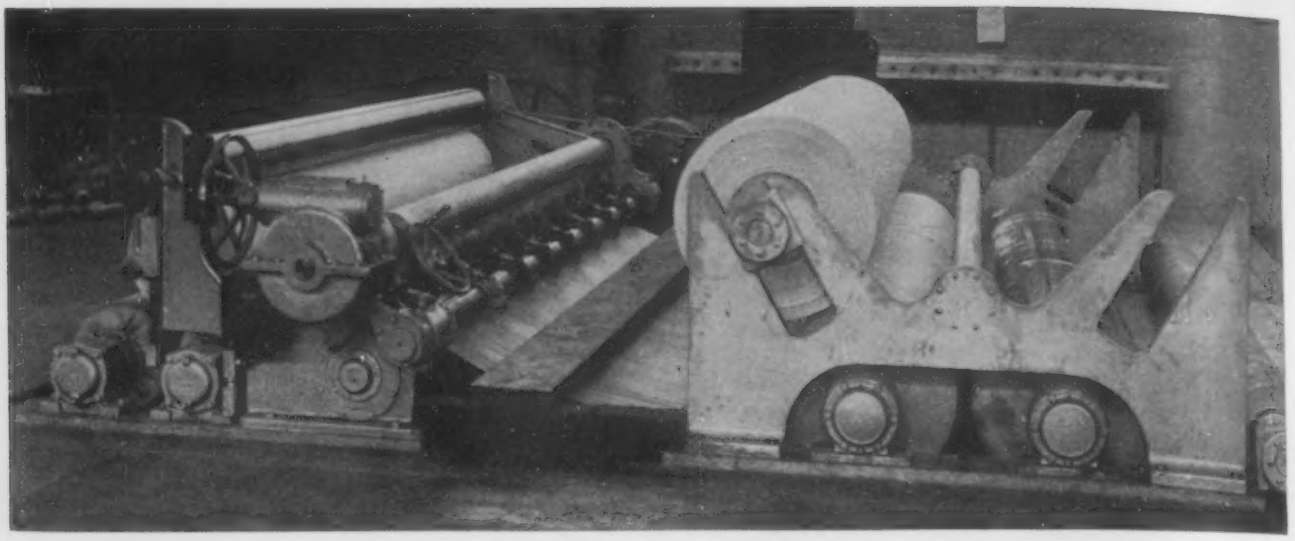


Fig. 19—View of Finishing End

sort of microscopic accordion action which breaks down the paper fibers and produces the soft textures of the tissues as differentiated from the hard finish papers. When it is considered that the paper film is approximately $^1/_6$ of the thickness of ordinary typewriter paper, it is apparent that the creping blade, or "doctor," must be mounted in very accurate alignment with respect to the dryer surface.

The doctor blade in itself is a thin sharpened strip of very hard bronze which is held against the dryer surface by a support which is pivoted axially at the ends so that the blade itself can be made to impinge against the dryer surface at the proper creping angle by rotating the support, as shown in Fig. 17. In this case, the reaction necessary for creping is furnished by a pneumatic cylinder which applies moment to the support through a lever.

It is the application of welding that concerns us primarily in the design of a proper support for this blade.

Ordinarily, a rolled angle iron is used for this purpose, and is apparently stiff and rigid enough to maintain blade alignment. However, there is a certain amount of mechanical vibration transmitted to the dryer from the driving mechanism which renders this type of mounting unsatisfactory on many machines. In the case of this machine, this effect has been minimized by the use of a chain drive; but in most applications, the drive is by spur gears, in which case the vibrational amplitude is more pronounced.

At any rate, the existing vibration is transmitted to the doctor support through the blade contact and bearings, and if the natural period of the support lies within the range of variable impulse rates as the machine speed is varied, a state of resonance may be reached that is highly injurious to the machine. It is possible in many cases to see the effects of this vibration in regular hills and valleys worn on the dryer surface by the doctor.

The effective method of combating this condition is to produce a doctor support with a high natural period so that it is entirely out of the range of driving mechanism impulse rates.

This is best done by using a stiff structure whose ratio of elastic modulus to weight is high. When it is considered that the nature of the loading is torsion as the blade is rotated up against the drum, the natural selection is a tube or pipe for economical fabrication.

The pipe, or tube, should be steel, and should be as large as is possible within the space limitations and have a comparatively thin wall, since the natural period is directly proportional to the square root of the moment of inertia and elastic modulus, and inversely as the square root of the weight.

The support and mounting are shown in Fig. 17.

Finishing Section

The calender frame (Fig. 18) is a variation of the press frame. Here, advantage is taken of the hollow section to incorporate the lever and pneumatic cylinder which loads the upper roll. This calender is small in comparison to most, but perfectly adequate for light weight papers.

The reel is a further adaptation of the standard section as are the slitter and rewinder. The unwind stand, Fig. 19, however, is an example of the economic use of the flat gas-cut plate, the frame being a single plate set on two pads which serve as feet and bolting flanges. The bottom is scarfed out to permit mounting the roll bearings on the foot plate directly, and although these rolls are a part of the mechanism do not mount on the frame.

As the paper is unrolled from the reels, the diameter is reduced, and since the rolls of paper rest directly upon the fixed drums, the centers move constantly inward until the cores rest on the driving drums. This construction requires that the bearing housing slide in guides. Here guides were provided by machining gas-cut slots in the plate frame.

A mental comparison can be drawn of the relative cost of this structure as built up of a single gas-cut plate and two small rectangular pads—and the cost of producing similar castings where only two such units are required

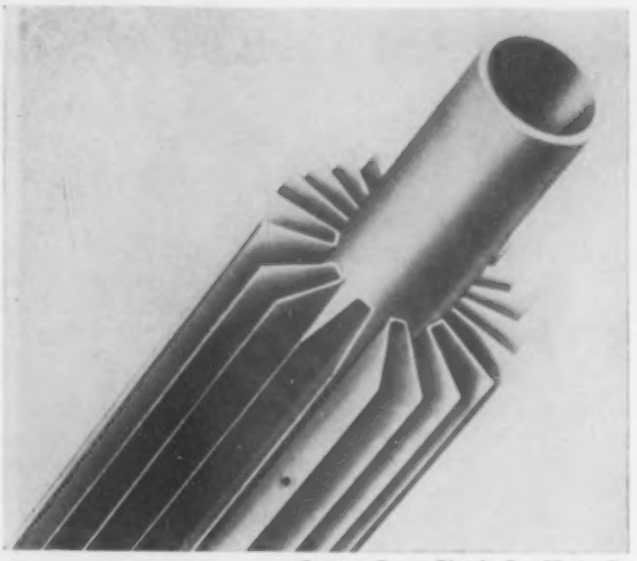
New Design of Fuel Oil Heaters Conserves Material

By H. S. Card*

MATERIAL economies are reflected in the design of fuel oil heaters installed in the Liberty Ships that are under construction for the Maritime Commission. A few of the details of this equipment indicate the extent to which modern refinements in fabricating and welding practice are advantageously used in the construction of this huge cargo fleet which is depended upon to carry a very large share of the supply burden throughout the War Emergency.

The hull of the Liberty Ships has a double bottom extending from peak to peak. This bottom is all tightly welded, making it suitable for carrying either fuel oil or salt water ballast. The fuel oil compartments are therefore in a comparatively cold location, making it necessary to provide some means of heating the fuel, for the double purpose of making it flow more readily and of improving the combustion rate. Two fuel oil heaters are installed in the engine and boiler room of the ship. Each of these heaters has a capacity to heat 35,000 lb. per hour of bunker C fuel oil from 100 to 230° F. when supplied with steam at 125-lb. gauge pressure.

Several manufacturers who specialize in the fabrication of heat transfer equipment have participated in the construction of the fuel oil heaters. The design of the heaters under discussion makes use of fintubes, which consist of electric-welded steel tubes to which longitudinal U-shape strip steel channels have been resistance welded on the outside. Thus, two electric resistance-welding processes are used to produce the heat transfer tubing: first, the welding of the rolled strip material to produce a round tube; second, the welding of formed channels to the tube wall. The fins provide a very large increase in exterior surface for the flow of heat from the hot steam to the cold oil. The fact that the fin is continuously welded to the main tube, providing a solid bond between it and the tube wall, assures a continuous and efficient heat transfer. The material savings are derived from the fact that the heat transfer capacity per lineal foot



Courtesy Brown Fintube Co., Elyria, O.

Fig. 1—Formed Steel Channels Are Welded to Wall of Plain Tubes to Produce Fintubes

Courtesy Heat Transfer Products Co., New York, N. Y.

Fig. 2—Fuel Oil Heater Units Being Pressure Tested Before Shipment

* Formed Steel Institute, Cleveland, O.

of the fintube is very high on account of the increased surface. In other words, one fintube can deliver the heat transfer service that would require several bare tubes of the same length. Further gains resulting from this effect are a smaller pressure drop, the possibility of using smaller shells of less weight and a considerable increased heat transfer capacity. By changing the number and depth of the fins it is possible to proportion the primary and secondary surfaces to the heat transfer coefficient of the material being heated or cooled, thereby compensating for a deficiency in the heat transfer rate of one or the other of the materials.

The welding method used in the manufacture of these fintubes results in what is literally a one-piece tube, permitting the heat to flow freely between the central member and the fins, and avoiding the opening up of any cracks or joints under expansion and contraction due to diameter changes. There is a considerable saving in steel tonnage which results from the use of fuel oil heaters built to this design, and still more important is the saving of thousands of feet of steel tubing for which there is a very heavy demand in connection with many phases of the War Production Program.

Residual Stresses in Welded Structures*

By Robert E. Kinkead†

LIKE most of the problems which arise in connection with electric arc welding, residual stresses may profitably be studied in some of the prior crafts of metal working. No small part of the difficulties we have had with residual stresses, and they have been many, come about because the practitioner has come upon the art and science of welding with the admonition that he would be dealing with something wholly new that was so far in advance of anything else that all prior craft could be neglected. I doubt that we shall ever discover anything that will not have its roots in what has gone before.

The most logical place to find prior craft in the matter of residual stresses is in the steel foundry. A steel casting and a welded structure have much in common. The welded structure ends up by being steel made by rolling, and held together by welds which are steel castings. So far as I have been able to find out, and I have had considerable acquaintance among able steel foundrymen, there is no single kind of erratic behavior we have ever known of in steel castings that had not been stress relieved, that has not had its match in welded steel construction that had not been stress relieved. In both cases, the structures squirm when being machined; they crack before getting into service; they virtually explode when subjected to impact in cold weather; they fail with a fracture showing that no plastic deformation took place. The erratic part of it lies in the fact that of two apparently identical structures or castings, one will fail and the other will not. Everyone knows what the steel foundry did to overcome the difficulties—they stress relieve the castings in a furnace, either as an incident to heat treating or as a separate safeguarding operation.

Stress relieving a welded structure in the furnace does, in fact, prevent erratic behavior from residual stresses incident to welding. If welding procedure has been such as to leave small cracks or extremely high residual stresses, the structure may crack locally in the furnace operation. This happens also in steel castings and in both cases proper welding repairs may be made.

We have three other cases to consider, the one in which the structure is of such a shape as to permit easy mechanical stress relief by loading, the structure which is so large that it cannot be put in a furnace and the case of welding techniques designed to prevent high residual stresses.

A cylindrical or spherical tank made up of welded components is easy to stress relieve by internal hydraulic pressure in excess of the working pressure and this method is approved by the A. S. M. E. Code for certain classes of unfired pressure vessels. In the vessels having heavy plate and of a class the failure of which would cause death and great destruction, stress relieving in the furnace is required. Many welded structures for mechanical purposes are effectively stress relieved by loading applied by hydraulic cylinders, by application of weights or otherwise producing unit stresses greater than the working load. What happens is that metal which is highly stressed incident to the welding operation simply passes through the yield point into the plastic range of deformation, thus dissipating the local residual stress.

A large oil storage tank, a bridge or a ship represents the case of the structure being too large to get into a furnace. But here the solution to the problem of eliminating erratic behavior may be worked out along the same lines that have been proved in pressure vessels. An oil storage tank is required to be filled with water. This will stress the structure beyond its normal unit stresses when filled with oil and stress relieve it very effectively. A bridge may be loaded with whatever is the most convenient, water tanks, sand bags. A ship may be loaded with water in her ballast tanks.

Some structures may be stress relieved by their first service loading. This requires the exercise of considerable judgment, where no previous experience with the type of structure involved is available. The important question, which arises where no previous experience is available, is related to the design of the structure itself and whether residual stresses might cause disastrous failure on first loading. A welded crane girder as now commonly designed illustrates the case of a structure which is not likely to fail on first loading regardless of residual stresses. A poorly designed ship is an example of a structure which may fail on first application of service loading. The temperature at which first loading is applied whether service loading or for the purpose of stress relieving will have an important effect. Thus a large crane shovel boom of welded con-

* Presented at the Annual Conference, Cleveland Section, A.W.S., May 14, 1943.

† Consulting Welding Engineer, Cleveland, O.

struction given its first loading in zero weather may fail in the plate due to residual stresses and low impact resistance of mild steel at low temperatures. There is always a certain amount of what might be called snapping and violent readjustment of a welded structure which has not been stress relieved when the first loading is applied. This sets up impact stresses which at low temperature in combination with residual and loading stresses are likely to cause failure.

The case of using a welding technique to prevent high residual stresses incident to welding is most interesting. Early in the history of welding ships in this country the Navy adopted a formula for manual welding of ships which has stood the test of time. It is simple. Start welding amidships, weld outboard, fore and aft, up and down, always stepping back. While it is difficult to weld up stepping back toward the center line—and I do not believe much of it is done—the procedure is sound, and when the additional requirement of keeping the welding balanced on the hull is followed, it works out pretty effectively. What the Navy does in terms of loading for stress relief by use of water ballast is information the Navy does not give out.

Stepping back is a procedure which was taken directly from the prior craft of riveting. The practice does effectively limit the degree of transverse residual stress but it does not affect the degree of longitudinal stress incident to the welding operation. Peening weld metal as it is applied and after both weld and plate have returned to ambient temperature is entirely effective in reducing residual stresses. The only valid objection to the practice is its cost.

From the engineering point of view we would seldom rely for safety on the assumption that any of the procedures designed to prevent or progressively reduce residual stresses had actually done so. There are too many doubts about whether a procedure was followed and the result actually attained. If the structure were of the type which should be stress relieved by loading before any service loading is applied, we would apply the load regardless of the procedure. In this event peening or whatever method was applied would be so much waste of time in so far as residual stresses are concerned. Correct procedure and sequence of welding are matters of importance in the welded assembly to prevent cracks which would otherwise occur, excessive deformation, etc., during the period of fabrication.

In my experience since modern practices have been followed I have never seen a structure being stress relieved by mechanical loading at a temperature above 45° F. fail where the cause could be clearly shown to be primarily residual stresses. I have seen structures fail for other causes under such loading. When the structure fails under these conditions no one gets hurt. The break is repaired by welding and retested. A break on such loading has a most salutary effect on the personnel.

Taking into account physical properties of the steel in large structures and those of the weld metal, it is difficult to conceive how residual stress could cause failure under static loading. Leaving armor plate out of consideration, weld metal has a higher yield point than steel plate commonly welded. No one would intentionally apply a load which would produce unit stresses above the yield point of the steel.

The purpose in removing or greatly reducing residual stresses is to protect the structure against failure due to reversal of stress, impact and erratic behavior due to biaxial and triaxial stresses. In dealing with the safety of the structure we are not concerned with whether failure originated in the weld or in the plate which has residual stresses incident to the welding. Unless the structure as a whole behaves under service loading exactly as if it were all one piece and made of the steel specified, its behavior is unpredictable. It will be unpredictable under the types of loading mentioned above so long as residual stresses are a factor in its behavior.

It is a fact that we have no non-destructive method of evaluating residual stresses in a structure. Even experience in building a number of identical structures of large size is unreliable. We can never be sure that the procedure and sequence were identical.

The way in which we deal with residual stresses in welded structures to make the structures safe is based on a vast amount of practical experience in prior crafts of metal working as well as on the experience of large numbers of able men who have built large welded structures successfully for many years. We are now in the most desperate and frightful struggle in our Nation's experience and the need for large welded structures is first on the list of urgency. Vast numbers of new and previously inexperienced personnel serve as workers and as supervisors and even engineers. It is to be expected that errors of judgment will be made, they undoubtedly have been made and will continue to be made. These things are just as unavoidable as the loss of brave and gallant officers and men on the field of battle due to their inexperience as soldiers. If the information I have is correct, the number of failures of large welded structures due to residual stresses, causing loss of life, is so small as to be one of the lowest hazards of the war. We will not know the whole story until after the war is over, and perhaps not then. I have undertaken to give a general over-all picture of methods of dealing with residual stresses in the hope that it will be useful to those who have to take the responsibility of making welded structures safe from failure due to these causes.

★★★

"The skipper said to the engineer, the parts of the new ship have not learned to work together yet....

"Every inch of her has to be livened up and made to work with its neighbor.... Our new little ship has to be sweetened yet and Nothing but a gale will do....All the hundreds of little plates that are riveted to the frames echoed the call, for each little plate wanted to shift and creep a little, and each plate, according to its position, complained against the rivets....

"And later, after the gale, there was just as much groaning and straining as ever but it was not so loud or squeaky in tone, and when the ship quivered, she did not jar stiffly, like a poker hit on the floor, but gave with a supple little waggle, like a perfectly balanced golf-club....

"For when a ship finds herself, all the talking of the separate pieces ceases and melts into one voice, which is the soul of the ship."

—RUDYARD KIPLING

From "Mechanical Vibrations"—Bernhardt.

Working Out Techniques for Welding Armor Plate*

By E. G. Biederman†

THE arc-welding process has opened an entirely new field of manufacturing, that of welded tanks. The methods that have been developed can be used on every type of welded fabrication, in many cases to a big advantage on present work, and to a tremendous advantage on future fabricating work.

Welded tanks are a necessity for saving human life. The riveted tank previously made would not stand the shell fire or shock, and this reason was enough to bring a new and better method to the front. This country must have thousands not hundreds of tanks. The arc welding process was a logical choice.

Through extensive developments, manufactures are holding tolerances that have previously been asked only from the machine tool industry and are learning every day that if more effort is put behind welding fabrication, the demand for machine tools is reduced tremendously. Riveting requires many times the amount of machinery. Most important is that through welding we will be able to manufacture tanks in large volumes and not be dependent on so many machine tools or on inadequate steel foundry capacity.

Welding eliminates hundreds of pounds of butt straps. This means less weight per horse power and increase in performance. Welding process saves a large amount of machine tools due to flame-cut edges and absence of drilled holes.

Early Trials

We started welding operations with different ferritic welding rods. This ended in complete failure due to the high hardenability of the high-alloy armor plate, and because we did not preheat and postheat or anneal. Failure was due to excess cracking at the fusion zone. Under shock firing, such plates fell apart with first shot. In these early experiments we did not make detailed studies of warpage or try to hold close limits in manufacturing due to the failure of the welds.

If armor plate specifications are changed to low enough alloys with low hardenability, ferritic rods should do the work, but at this date such steels do not exist for manufacturing purposes that will pass ballistic and shock tests as set up by the U. S. Army Ordnance Department.

Next, tests were made with an austenitic electrode. This rod was more successful and sound welds were made which passed Aberdeen Proving Ground tests. Using the above rods, however, caused a series of troubles such as root bead cracking and excessive grinding and chipping was required.

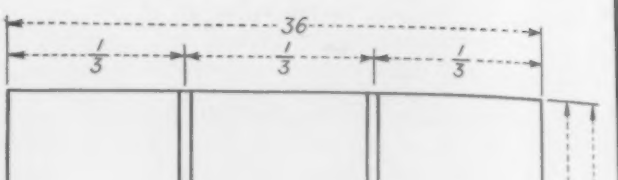


Fig. 1—Standard H Plate Weldment Used at the Aberdeen Proving Ground for Subjecting Fabricated Armor Plate to a Ballistic Shock Test

At this time, too, alloy rods were hard to get and it looked as if this rod would not be available for tank manufacture.

Welding electrode manufacturers started to develop a lower-alloy rod for welding high-alloy armor plate of high hardenability. Better results were obtained. There were less cracking in fusion zone and less cracking in weld metal. The material also had better ballistics for weld deposits.

The deciding test is the shock test developed by Aberdeen Proving Ground. This consists of an H-plate weldment 36 x 36 in., Fig. 1, wedged into a standard and fired at by a 75-mm. gun at 100 yd. The shell did not penetrate the weldment but was used to give the weld a very severe shock. The outcome was that besides saving alloys, a better rod was found for manufacturing tanks. An actual saving of approximately 33% was made in the cost of welding electrode and in the use of chrome nickel alloys.

Welding Technique

Present everyday welding procedures were found inadequate in manufacturing tanks. There are very few fabrications in low carbon steel or otherwise that must stand inspection shock test of a 75-mm. shell fired point blank or that must be held to such close tolerances in

* The author describes a number of experiments conducted to determine the most successful methods for welding armor plate for combat tanks and shows which welds stand up best in ballistic impact tests. This paper won one of the awards in the recent $200,000 industrial progress award program conducted by The James F. Lincoln Arc Welding Foundation. Possible annual cost savings of almost $2,000,000,000 by arc welding were shown by the many papers submitted. This paper was also published in *Iron Age*, Jan. 21 issue. This reproduction while not an exact copy has taken advantage of some of the editorial work of *Iron Age*, and acknowledgment is made herewith of this fact.

† Fisher Tank Division, Flint, Mich.

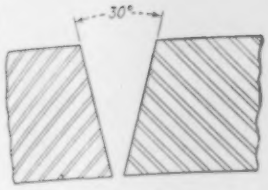


Fig. 2

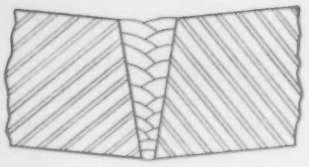


Fig. 3

Fig. 2—This Type of Plate Preparation Has Not Proved Successful for Welding Armor Plate

Fig. 3—Exaggerated Example of Warpage Resulting from Shrinkage in a Single V-Type Weld

building. This meant a new development of plate edge preparation to keep warping to a minimum.

All plate edge preparation is done with the flame-cutting method. This means flame cutting must be held to much closer tolerances. No edge for welding should be done otherwise because of the savings possible. If edges are machined it means tying up machine tools and labor and takes a lot more plant space. It is almost impossible to estimate this saving in dollars and cents, but it is tremendous. It has now been proved that a flame-cut edge can be held within limits for tank building.

The single V of 15, 20, 30 or 40° has been in use as a standard plate edge preparation for normal welding fabrication. This preparation, however, has not been successful for welded tank manufacturing.

A weldment made with a 30° included angle, Fig. 2, was very unsatisfactory. Despite use of extensive fixtures made to hold welded parts, warpage from shrinkage, Fig. 3, could not be controlled. After trying 20, 30 and 45° single V's, these angles were discontinued except for test purposes.

Tanks must be fabricated by welding and hold tolerances of $^1/_{64}$ in. at places where parts bolt to the tank such as the front-end drive, suspension wheels, idler brackets, turret ring and a lot of other assemblies. Close dimensions like these have never been held before on a fabricated part. They were always welded and then machined. Even if it were possible to machine different areas of the tank, the machines are not available. That is why we must weld and hold tolerances just the same as machine parts. The double V was then adapted, Fig. 4. It takes double the edge preparation that a single V takes, but it was found to be the answer for weld strength and the only possible way to hold tolerances throughout tank manufacturing on a production basis without using machine tools.

The double V has been used before but never had to be held to tolerances required for tank production. A certain bead technique had to be used to control warpage. With a standard root bead, Fig. 4, shrinkage takes place and that is when the plates warp. The welded part must then be turned over and welded from the opposite side. This procedure must be followed to equalize stresses. When this is done, it is possible to hold dimensions without stress relieving and machining.

Development of the root bead was very important as the root of the weld is the foundation of a good weld. First, root beads were welded with a 45° included angle and an opening. This is a very impractical procedure as the weld metal runs through and the back side must be chiseled out or ground, Fig. 4 (*C*). Chiseling is very bad on stainless steel as the metal is austenitic and work hardens. The chisel just pounds against a solid formation. Grinding, on the other hand is time consuming. Relatively it amounts to 30 min. of welding and 180 min. of grinding. We discontinued the procedure because it did not lend itself to the manufacture of tanks.

Copper Backing Strip

The next experiment of welding a root bead was with a copper backing. Two plates were set up with a 45° included angle and an opening. A copper bar was then

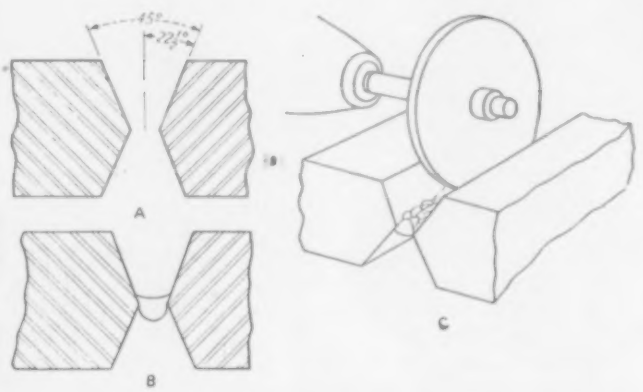


Fig. 4—The Trouble with a Double V Plate Preparation *A* Is That the Weld Metal Runs Through as at *B* and the Weld Metal on the Back Side Must Be Ground Out at *C* Since Chiseling Out Is Impractical on Austenitic Stainless Steels Which Work Harden

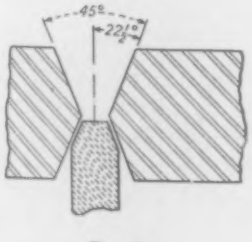


Fig. 5

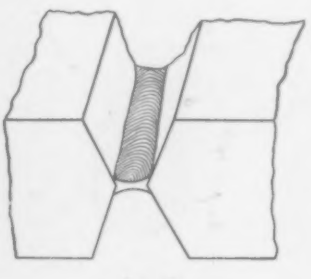


Fig. 6

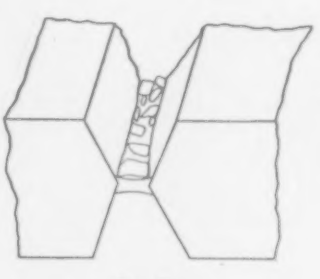


Fig. 7

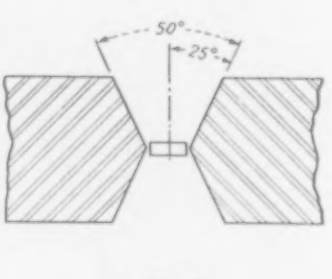


Fig. 8

Fig. 5—Use of a Copper Backing Bar Prevents the Weld Metal from Running Through the Opening Left Between the Plates

Fig. 6—Appearance of Top Side of First Bead Laid Down with the Copper Backing Bar Underneath, as Shown in Fig. 5

Fig. 7—Appearance of the Under Side of the Weld Illustrated in Fig. 6, Showing the Effect of the Copper Backing Bar. The Concave Areas Make an Ideal Surface for Receiving Other Weld Beads

Fig. 8—As an Experiment, a Mild Steel Strip Was Laid in the Opening Between the Double V Plate Edges. This Technique Was Not Successful

inserted in the under V and had about $^1/_{32}$-in. clearance on each side, Fig. 5. It was then welded in down-hand position from the top side.

After root bead was welded, the copper bar was taken out and the root bead was inspected from both sides. Figure 6 shows the top side and Fig. 7 the side where copper received weld metal. No grinding or chipping was necessary, and where copper received weld metal there was a concave surface formed which is an ideal condition for receiving other weld beads. There were not any voids, which make for an unsound weld, and the weld was in condition for receiving other beads by just removing the slag.

The next test of a root bead was made with a mild steel strip between a double 50° included angle with an opening, Fig. 8. This method eliminated weld metal coming through but left voids between the strip and the weldment. This weld obviously was not good enough because it did not have complete penetration.

It was then decided to weld the steel strip from one side and chip it out so a sound weld could be made, Fig. 9. But this procedure was eliminated because it was almost impossible to chip strip out of corners or around bulkheads in the tank. It was then thought to use a gouging tip on an acetylene torch. Gouging the strip out was better than chipping but this was difficult to maneuver around corners of the tank and it left a certain amount of carbon deposit that was a detriment to the weld. This was eliminated as not being good for production and quality weld.

We then developed a diamond-shaped or oval stainless steel strip that would not have to be chipped or flame gouged. This was successful as it would lend itself to production and would also make a good weld as complete penetration was possible, using the copper backup, Fig. 10.

Next came the problem of developing the proper bevels for welding. It was decided that a double 45° included angle with an opening would be tried as it would not use excess weld metal in heavy plate. A copper backup was used on these plates, the same as in Fig. 10. After a few H plates were tested ballistically it did not look as if our welds were good enough. Most all the breakage was what is commonly known as a fusion zone break. At this time we did not really know all the factors involved in a fusion zone break.

We then decided to make other tests with a 50° included angle with an opening and a copper backup. After making a series of H welded plates this way, we found that the fusion zone cracks were almost entirely eliminated. The welding was done with the same welder as before and using a weave technique. That told us that the bevel used was very important when welding a high-alloy armor plate with a high hardenability.

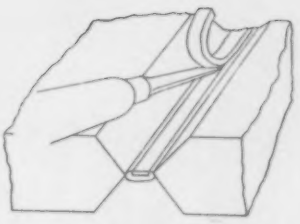


Fig. 9

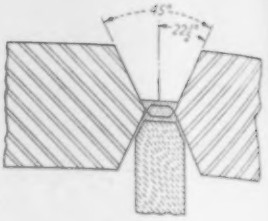


Fig. 10

Fig. 9—Chipping Out the Mild Steel Strip After a Bead Had Been Laid on One Side Was Tried, But Was Abandoned Because of the Difficulty of Getting the Strip Out of Corners. Flame Gouging Was Also Tried and Abandoned

Fig. 10—Use of a Diamond-Shaped Stainless Steel Strip in the Opening Between the Plates Worked Out Successfully and Lent Itself to Production Inasmuch as no Subsequent Chipping or Gouging Is Required to Produce a Sound Base for the Other Beads

We then decided to make a series of H welded test plates with different plate edge preparation. We felt that if the test plates failed, so would the tanks fail.

Effect of Plate Bevels

The first plate was prepared with a 25° included bevels as shown in Fig. 11. The second plate was prepared with a 45° included bevel, Fig. 12. The third plate was prepared with a top and bottom bevel of 90° included angle, Fig. 13. The fourth plate was prepared with a top and bottom bevel of 104° included angle, Fig. 14. All H plate weldments were welded with the same rod and the same welder and all had a copper backing bar such as the figures show.

After these plates were shock fired we then knew that the bevel played a very important part in welding and manufacturing tanks. It showed that a lot of fusion zone cracks occurred because the bevel was too straight and the hard zone at the fusion point would let go because it was almost in line with the line of shock. By keeping the hard zone from almost a direct line of fire, we achieved very good results.

These tests proved to us that no bevel should be less than 45° and that if at all possible we should avoid bevels

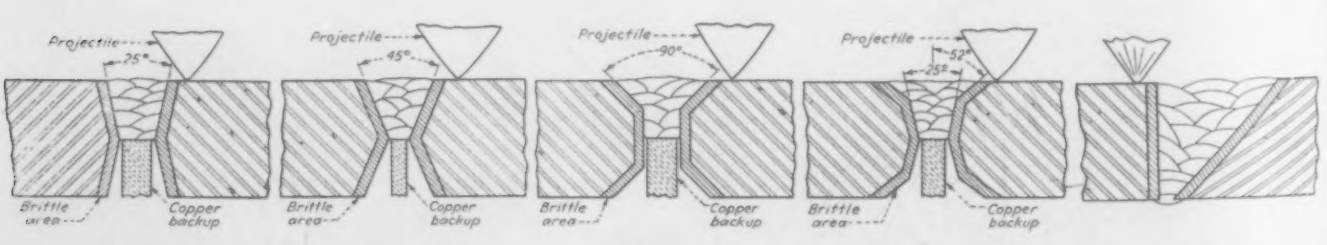


Fig. 11 Fig. 12 Fig. 13 Fig. 14 Fig. 15

Fig. 11—This Welded Plate Failed to Pass the Shock Test Because the Angle of the Surface Adjacent to the Weld Was Not Great Enough to Prevent Shearing Action in the Brittle Area Next to the Weld

Fig. 12—This Type of Weld Passed the Shock Test Because the Angle of the Surface Adjacent to the Weld Was Great Enough to Prevent Shearing Action in the Brittle Base Metal Area Next to the Weld

Fig. 13—This Type of Weld Also Passed the Shock Test for the Same Reason as Given in Fig. 12

Fig. 14—This Plate Also Passed for the Same Reason as Given in Fig. 12

Fig. 15—Welds Will Generally Break Through on the Straight Side of Such a Joint Because the Hard Zone Created in the Parent Metal Is in Line with the Shock Created by the Projectile

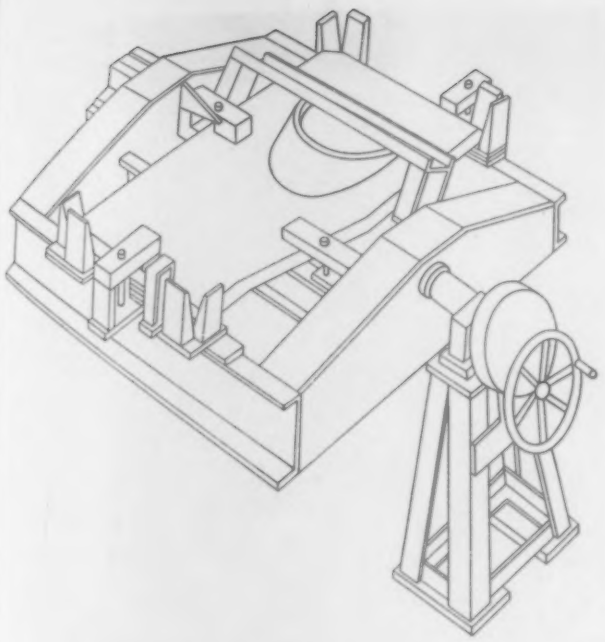


Fig. 16—Combination Welding Fixture and Positioner. This Arrangement Permits Turning Over the Subassembly After Each Bead Is Laid so as to Equalize Stresses and to Use All Down-Hand Welding

on one side and straight on the other side. Welds will generally break through on straght side because hard zone is in line with shock, Fig. 15. All tests were made with same welder and same rod. After these tests we knew which plate edge preparation was best.

The next step was to prove what armor plate was the best for welding. Four types were agreed on. After receiving 16 plates, four from each source, we then prepared them all the same 45° included bevel with a root opening. All 16 plates were welded with the same welder, same rod and the same technique.

After these tests, we were able to determine the most weldable armor plate. The tests will also help the armor plate manufacturer to make better plates for welding.

Electrodes Tested

We then decided to find out which rod was the best for welding armor plate. Again we took 16 plates but all from one source and decided to weld them as follows: Rod manufacture "A" four plates, Rod "B" four plates, Rod "C" four plates, Rod "D" four plates. After these tests were completed we then knew which rod was the best. When we had this evidence all the rod manufacturers were informed and they changed their coatings accordingly. All are supplying satisfactory rods now.

Considering the cost of such welding, savings from less rejects can only be estimated, but they more than justify any cost of extensive experiments. A few more miles obtained from each tank in actual combat may mean the winning of a crucial battle.

Based on the experience and the data from these tests, we started building fixtures and manufacturing tanks. As previously mentioned the one big problem was warpage and how to control it.

All the fixtures were designed so that all welds could be made down hand and that fillet and butt welds could be made from both sides. This latter requirement is necessary in order to equalize stresses. Figures 16 and 17 show typical fixtures and positioners which permit turning the work over for welding the underside.

The first tank was welded on a surface plate and it was difficult to equalize welding from both sides. We immediately found that by neglecting the equalizing technique our dimensions were very hard to control. Also, we had welds that sheared apart due to stresses from welding more on one side than the other. From this trouble we learned that it is necessary to equalize the shrinkage stresses on all of our welds. It was then found that our dimensions were easy to hold and we did not encounter any more weld cracking or shearing from warpage or stress from welding. Each part is first made as a subassembly, then checked OK, so it can be set up in the next fixture easily and quickly.

After quality is determined, equalizing stresses is the biggest factor in welding tanks. It means you can make up subassemblies and know they will fit into the following fixture and assembly quickly. Also, when the tank is completely welded, it will stay in good condition longer. If you do not equalize the welding stresses, undue work or shock stress at some point that is already stressed to its maximum will fail. The welds break or twist to favor the stress. If subassembly methods are used, it will be possible to build many more tanks due to the fact that parts can be welded any place and final assembly involves only a few big fixtures, instead of having all final assembly fixtures. This is a very vital necessity in saving time, fixture expense, floor space and machine tools.

Vital Saving Made in Labor

Labor savings also can be effected as the smaller fixtures can be worked from the floor; the men must climb into the larger fixtures. Hence, in using more small fixtures and less large fixtures, welding operators will be able to weld more inches per hour. This is important as welders will be scarce. Estimated saving with this layout can be tremendous.

The main objective is to produce tanks and armored vehicles in the least time possible, and have equipment superior to any that will be met in combat. To accomplish this, the foregoing techniques were worked out and are recounted in this article for one purpose—to win. This objective can be attained by getting into production quickly and by producing faster for less money.

The real savings can only be determined by the value placed on our winning the final decision.

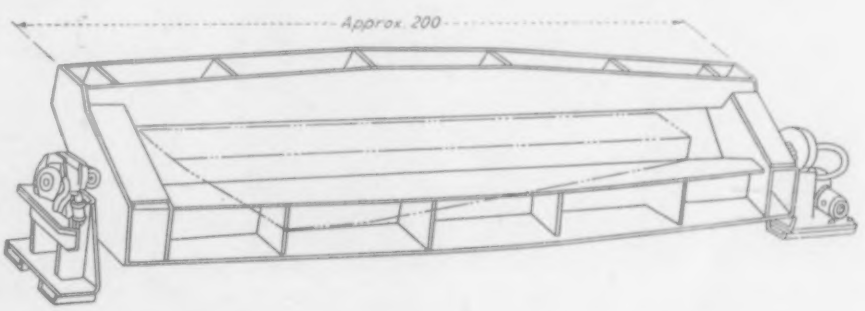


Fig. 17—Another Type of Fixture Used in Welding Large Tank Components

Skill and Ingenuity of Arc-Welding Job Shops Shown in Production of Numerous Small Items

By C. M. Taylor*

OPERATORS of job shops throughout the country are demonstrating their knowledge of electric arc-welding design and techniques through practical application on a multitude of small welding jobs.

Figures 1 and 2 illustrate one typical example. In this case, a soft drink manufacturer, unable to obtain additional clamps needed for his bottling machines, submitted the problem to a local welding shop.

Using one of the standard cast-iron clamps as a guide, the welder fabricated new clamps by arc welding together 3 pieces of 1-in. square bar stock, and rounding the edges by grinding as shown at left (Fig. 1).

* Vice-President, The Lincoln Electric Co., Cleveland, Ohio.

Fig. 1—Partially Complete Clamp (Left) Weld-Fabricated to Duplicate Cast-Iron Clamp (Right)

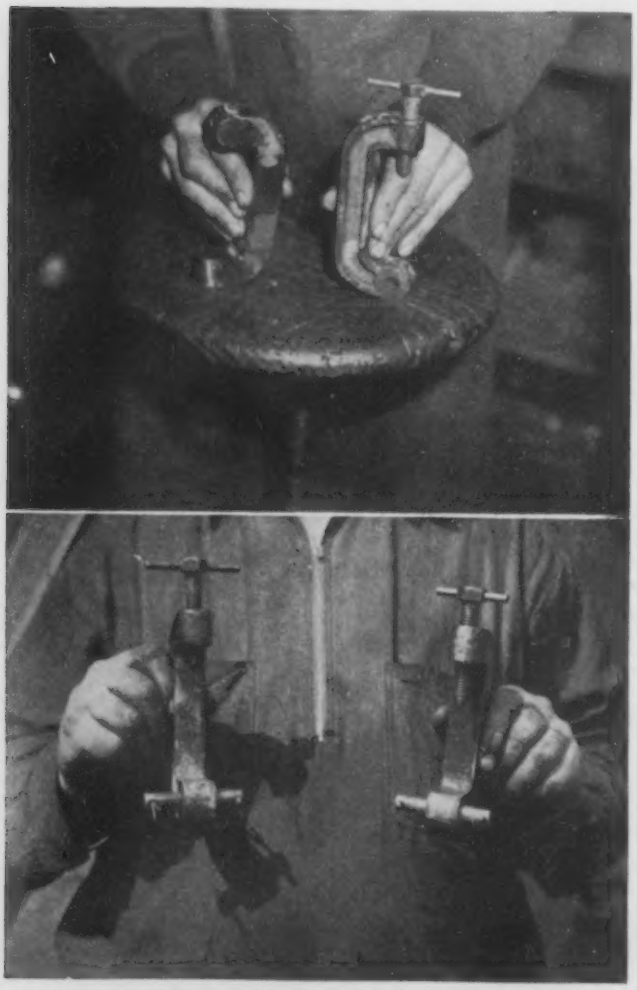


Fig. 2—The Finished Arc-Welded Clamp (Right) Shown Is Typical of Small Jobs Turned Out by a Job Welder. Old Cast-iron Clamp Is Shown at the Left

Fig. 3—Agitator Frame for Sewage Disposal Plant Is Arc Welded at Corners After Forming Two Pieces of Angle Iron Into Ell Shape. A Quantity of These Frames Was Completed in a Few Hours

The bar stock was placed in a positioning fixture so that the pieces formed a full corner joint. Welds were applied to both sides of the joint, several passes being necessary to fill the outside vee opening.

Holes were then drilled in the ends, one hole being threaded for the thumb screw.

The arc-welded clamp shown at right (Fig. 2) was much stronger than the original clamps and excessive breaking, experienced with the cast clamp, was eliminated.

A simple arc-welded frame of 1-in. angle iron is shown in Fig. 3. These frames, produced in quantity, are of 2-piece construction, requiring simple butt welds at the two corner joints.

The frames, which are 17 1/2 in. by 40 in., were ordered by a sewage disposal plant.

Electrode size used was 1/8-in. Entire frame is cut, shaped, arc welded, and excess weld ground smooth in less than 1/2 hr.

A unique work table built of salvaged scrap metal by an Ohio operator is illustrated in Fig. 4.

An old automobile transmission shaft with socket joint was used as the principal part of the positioning fixture shown at center in Fig. 4.

The weld-fabricated "C" clamp welded to the shaft has a nut on the end to accommodate a thumb screw.

A circular plate of 1/2-in. iron forms the bed of the table which can be revolved in either direction.

Several sizes of iron blocks are fillet welded to the table top for forming operations.

Fig. 4—Efficient Rotating Work Table with Positioner and Forming Fixtures Arc Welded of Scrap Material. Plough Share, Rebuilt by Electric Arc, Is Shown in Positioner Clamp

Two-inch pipe sections were arc welded on an angle to the 6-in. pipe base for holding extra electrodes.

The table increases the efficiency of the welder and helps him increase his volume by speeding up the work.

Figures 5 and 6 illustrate 2 hand trucks made for use around the welding shops.

The lighter-weight truck (Fig. 5) consists of 2 lengths of 1-in. tubing, with connecting members of $1^1/_2$-in. strap iron.

Scrap plate $^1/_8$-in. in thickness was cut, formed and welded to construct the base of the framework.

Wheels and axle are from a discarded lawn mower.

Fig. 5 Fig. 6

Fig. 5—Light-weight Hand Truck Arc Welded of Scrap Metal and Old Lawn Mower Wheels and Axle

Fig. 6—Heavy-duty, All-welded Hand Truck for Carrying Heavy Parts and Machinery Around Shop

Truck is used for conveying items weighing up to 500 lb.

The heavy-duty hand truck (Fig. 6) is of similar arc-welded construction and is exceptionally light in weight as compared to the heavy machinery and parts it can carry.

Savings for welding shop operators and customers alike are being effected daily in hundreds of communities where arc welding has become the standard fabrication and repair practice.

Annual Meeting

AMERICAN WELDING SOCIETY

WEEK OF OCTOBER 18, 1943

SOCIETY HEADQUARTERS—HOTEL MORRISON, CHICAGO

In order not to be disappointed, members of the Society are urged to make reservations promptly by writing to Leonard Hicks, Jr., Morrison Hotel, Chicago. It is imperative that these letters mention the name "American Welding Society Convention."

The rates for single rooms are $3.30, $3.85, $4.40, $5.50. The rates for double rooms are $4.40, $4.95, $5.50, $6.60, $7.70, $8.80. Rooms with twin beds are from $5.50 up. A large number of suites are available ranging in price from $9.90 on up depending upon the number of rooms and space.

Inasmuch as it is believed that the Hotel will be filled, members are requested to indicate their exact stay so that the rooms may be rented to members coming in later.

PROPOSED CODE OF MINIMUM REQUIREMENTS FOR INSTRUCTION OF WELDING OPERATORS

Part B-1—Oxyacetylene Welding of Steel-Aircraft

IMPORTANT NOTICE:

Part B-1 of the Code presented hereinafter was prepared by the A.W.S. Committee on Minimum Requirements of Instructions for Welding Operators in Trade Schools.

Part A—Arc Welding of Steel 3/16 to 3/4 In. Thick, has already been approved and published in pamphlet form and is available from Society Headquarters.

Part B-1 is being published for the purpose of securing comments, criticisms and suggestions, and has not yet been approved by the Society.

To be considered, any correspondence regarding this Code should be addressed to the Secretary of the Committee on Minimum Requirements of Instructions for Welding Operators in Trade Schools, AMERICAN WELDING SOCIETY, 33 West 39th St., New York, 18, N. Y., to arrive not later than August 16, 1943.

FOREWORD

In preparing this Code of Minimum Requirements for Instruction of Welding Operators, the field of instruction in steel welding was subdivided into four basic courses, namely: (1) arc welding of thick material; (2) arc welding of thin material; (3) gas welding of thick material; (4) gas welding of thin material. A tentative code covering the first of these subdivisions has already been approved by the Society on July 20, 1942, and published under the subtitle "Part A—Arc Welding of Steel 3/16 to 3/4 In. Thick." For Part B the Committee elected to treat the fourth subdivision, namely, gas welding of thin material. Because of the present urgent need for standards of instruction in the field of aircraft welding, Part B is further subdivided into two sections. The first section, Part B-1, is titled, "Oxyacetylene Welding of Steel-Aircraft." The second section, Part B-2, is to be titled, "Oxyacetylene Welding of Steel Up to 3/16 In. Thick."

There are two principal classifications of welding operators in the aircraft industry, defined by the type of work each is required to perform.

Class A operators are certified to perform welding operations on *any* steel aircraft parts; Class B operators are certified to perform welding operations on less important aircraft parts. Part B-1 of the Code, as presented hereinafter, sets forth two prescribed courses as follows:

1. Course I is intended for those trainees possessing little or no prior training as welding operators. Completion of this course prepares the trainee for work as a Class B operator.

2. Course II is intended for those trainees who have been certified as Class B operators as evidenced by either completion of Course I or a proven equivalent amount of practical experience. Completion of this course prepares the trainee for work as a Class A operator.

Part B-1 consists of two principal parts, namely: (1) a mandatory part and (2) a non-mandatory part as follows:

1. Mandatory.—That part contained in Sections I to VI, all provisions and requirements of which must be fulfilled by any welding course which is to be considered as complying with this Code for the training of class A operators; welding schools representing as training Class B operators only shall conform to the several Sections, Articles and subdivisions thereof, indicated as applying to Course I; welding schools representing as upgrading Class B to Class A operators only, shall conform to the several Sections, Articles and subdivisions thereof, indicated as applying to Course II.

2. Non-mandatory.—That part contained in Appendices A to H, which represents suggested material intended to aid welding schools in complying with the mandatory provisions.

SECTION I—GENERAL

101. Definition of Terms

Oxyacetylene Welding: A gas-welding process wherein the welding heat is obtained from the combustion of oxygen and acetylene.

Related Information: For the purpose of this Code, Related Information shall be interpreted as covering lectures and demonstrations on safety, operation and care of equipment, elementary welding metallurgy, welding techniques, inspection and testing of welds, terminology and industrial applications.

Welding Operator: An operator of welding equipment.

Hereinafter in Part B-1 of this Code, the term welding operator shall be interpreted as an operator of manual oxyacetylene welding equipment performing the welding operation.

Welding Station: The area and equipment assigned to one trainee for performing welding exercises.

Other welding terms shall be interpreted according to the AMERICAN WELDING SOCIETY "Definitions of Welding Terms and Master Chart of Welding Processes."

102. Scope

Part B-1 of this Code prescribes minimum requirements for a course of instruction in manual oxyacetylene welding as applied to carbon or alloy steel of the types approved for aircraft construction, in thicknesses ranging up to and including 1/4 in.* These requirements include principally: (1) equipment and facilities of the school, (2) qualifications of the instructor, (3) content of the instruction in welding practice, (4) content of the instruction in welding theory, and (5) tests which the trainee shall be required to pass before completing the course. This Code is intended to apply to public vocational schools and privately owned trade schools preparing operators for other than their own use.

103. Objectives of Course

The objectives of the course shall be: (1) to train the trainee in the fundamental techniques and safe practices† of oxyacetylene welding; (2) to give the trainee a thorough understanding of the proper methods of oxyacetylene welding, as applied to steel of thicknesses ranging up to and including 1/4 in.; (3) to have the trainee acquire enough welding skill to en-

* This course is intended to cover the welding of steel sheet and tubing, and plate up to and including 1/4 in. thick.

† A list of recommended safety rules for welding schools is given in Appendix C.

(*b*) Upon completion of Course II as prescribed for the training of Class A operators, the trainee shall be granted a Record Card witnessing thereto.

This Record Card shall indicate that the trainee has passed the tests as prescribed in Section VI which pertain to Course II. Further, these tests

give the trainee a thorough understanding of the proper methods of oxy-acetylene welding, as applied to steel of thicknesses ranging up to and including 1/4 in.; (3) to have the trainee acquire enough welding skill to enable him to pass the qualification tests prescribed in Section VI; and (4) to provide the trainee with a knowledge of welding theory sufficient for the work he is to do.

The course is not expected to produce an experienced operator, but rather an operator with enough skill and knowledge so that he will have immediate value to industry as a welding operator on less difficult work, and will be able, by gaining experience in industry, to progress rapidly to work of greater difficulty and responsibility.

104. Selection of Trainees

Trainees selected to receive the instruction prescribed in this Code shall have the following qualifications:

(*a*) Ability to understand the language of instruction to the extent required for comprehension of the instruction prescribed in Sections IV and V.

(*b*) No physical or mental disability that precludes safe operation of welding equipment or interferes with full performance of duties in industry.

(*c*) Eligibility to meet the minimum age requirements prescribed in the State and Federal Labor Laws applicable in the state in which the instruction is conducted, upon completion of the course.

105. Trial Period of Instruction

At the beginning of the course there shall be a trial or probationary period not to exceed 30 hours, the period to be determined by the school, during which the instructor shall observe the aptitude and interest of the trainee and determine whether in the interests of all concerned the trainee shall continue the course.

106. Record Card (Evidence of Completion of Course)

(*a*) Upon completion of Course I as prescribed for the training of Class B operators, the trainee shall be granted a Record Card witnessing thereto.

This Record Card shall indicate that the trainee has passed the tests as prescribed in Section VI which pertain to Course I. Further, these tests, together with the results of said tests, shall be listed on the Record Card. Also this Record Card shall contain the following:

Prominent marking with a large "B."
Title of Course.
Duration of Course, Total Hours.
Hours of Actual Welding Practice.
Hours of Observation of Welding, Preparation of Material, Testing, etc.
Hours of Instruction in Related Information.

A suggested form for This Record Card is shown in Appendix G.

(*b*) Upon completion of Course II as prescribed for the training of Class A operators, the trainee shall be granted a Record Card witnessing thereto.

This Record Card shall indicate that the trainee has passed the tests as prescribed in Section VI which pertain to Course II. Further, these tests together with the results of said tests, shall be listed on the Record Card. Also this Record Card shall contain the following:

Prominent marking with a large "A."
Title of Course.
Duration of Course, Total Hours.
Hours of Actual Welding Practice.
Hours of Observation of Welding, Preparation of Material, Testing, etc.
Hours of Instruction in Related Information.

This Record Card may be of the same general form as the Record Card issued at the completion of Course I for Class B operators, but should have some obvious means to permit ready differentiation.

A suggested form for this Record Card is shown in Appendix G.

If all Final Tests listed in Section VI are shown on this card, means should be provided for permanently indicating those tests which the trainee has not taken or passed.

When used for Course II, the Record Card shall indicate the results of the tests performed by the trainee at the completion of Course I or a statement attesting the successful completion of these tests.

SECTION II—EQUIPMENT AND FACILITIES OF THE SCHOOL

201. Apparatus

(*a*) *General*

In order to assure the safety and adequacy of the welding equipment, all the oxygen and acetylene equipment shall be approved by one or more of the nationally recognized approving agencies.*

(*b*) *Welding Stations*

Each welding station (see definition in Article 101) shall have an area of not less than 16 sq. ft., and shall have sufficient *clear* floor space to allow the trainee adequate freedom of movement. Stations shall be so arranged that there is a distance of not less than 4 ft. between trainees in neighboring stations, unless fire-resistant shields are provided to separate the stations. The school shall be equipped with at least two-thirds as many welding stations as there are trainees in the shop class.

(*c*) *Welding Tables*

Welding tables shall be constructed of non-combustible frame work and

* Apparatus must be listed under the label or re-examination service of Underwriters' Laboratories, Inc., or approved and listed by Factory Mutual Laboratories. Installations shall meet the standards of the National Board of Fire Underwriters or the Associated Factory Mutual Fire Insurance Companies.

top, and shall have a tabletop area of not less than 4 sq. ft. (24 in. by 24 in.). An individual table for each welding station is preferable. In the event that a large table is used for a number of trainees, adequate fire-resistant shields shall be provided between the separate welding stations, and the tabletop area within each station shall not be less than 4 sq. ft.

(*d*) *Gas Sources*

A source of oxygen and of acetylene shall be provided for each welding station. The oxygen may be piped from an oxygen manifold and the acetylene from an acetylene manifold or generator; or each station may be supplied with a portable outfit consisting of one oxygen cylinder and one acetylene cylinder on a suitable truck or otherwise held so that they cannot be accidently overturned. Each cylinder or station outlet shall be provided with suitable regulators.

(*e*) *Welding Torches*

Each welding station shall be provided with a welding torch of a size suitable for the thickness of material to be welded. Each torch shall be supplied with adequate lengths of oxygen and acetylene hose and with tips of different sizes appropriate for the range of thickness of material covered in the welding exercises prescribed in Section IV. The welding torches should preferably be of different makes in order that the trainee may acquire experience with as great a variety of oxyacetylene welding equipment as possible.

(*f*) *Welding Rods*

There shall be provided an adequate supply of gas welding rods of the types and sizes required for the exercises prescribed in Section IV. Welding rods shall conform to the A.W.S-A.S.T.M. Tentative Specifications for Iron and Steel Gas Welding Rods (Serial Designation A-251) as given in Appendix D.

(*g*) *Materials for Welding*

The school shall furnish an adequate supply of carbon or alloy steel sheet, tubing and plate of the types approved for aircraft construction as required for the exercises prescribed in Section IV.

(*h*) *Testing Apparatus*

The school shall possess apparatus suitable for preparing and testing the tension test and guided-root-bend test specimens described in Articles 401 (*d*), 603 and 605, or shall have facilities for having these test specimens prepared and tested elsewhere.

(*i*) *Miscellaneous*

In addition to the foregoing, the school shall provide all other apparatus and equipment necessary for the safe and proper execution of the welding exercises prescribed herein. A list of suggested accessory equipment is given in Appendix A.

202. Supervision

(*a*) *Number of Trainees per Instructor*

Each shop class shall be restricted to not more than 16 trainees in attendance per instructor.

(*b*) *Record of Trainee's Progress*

A visible record shall be kept of each trainee's progress, showing the number of hours of individual welding practice, and the results of all tests prescribed in Sections IV and VI. A suggested form of trainee progress chart is shown in Appendix F of this Code. An attendance record shall also be maintained.

203. Length of Course and Hours of Instruction

(*a*) *Length of Instruction in Welding Practice*

The instruction in welding practice shall be so organized that each trainee shall be required to devote the minimum number of hours stipulated below to actual welding, exclusive of time spent in witnessing demonstrations by the instructor, preparing material for welding, testing specimens, observing the work of other trainees and receiving instruction in welding theory.

(1) For trainees taking Course I in preparation for the Class B tests as prescribed in Section VI, the minimum number of hours of actual welding practice shall be 150.

(2) For operators possessing Class B qualifications and taking Course II in preparation for the Class A tests as prescribed in Section VI, the minimum number of hours of actual welding practice shall be 100.

(*b*) *Related Instruction*

The related instruction for each course shall include the material outlined in Section V.

(*c*) *Length of Welding Practice in Any One Day*

The length of time spent by the trainee in actual welding practice in any one day shall not exceed 6 hours.

204. Reference Materials

(*a*) *Outline of Course*

At the start of the course, each trainee shall be acquainted with the scope of the course.

(*b*) *Welding Publications*

The school shall have available for the trainees' use, reference materials consisting of current books, manuals, periodicals, codes and standards pertaining to welding, including the following publications:*

* Except where noted, this material is published by the AMERICAN WELDING SOCIETY

† Code of Minimum Requirements for Instruction of Welding Operators, Part B-1—Oxyacetylene Welding of Steel-Aircraft.

† Safe Practices Pamphlet No. 23—Gas Welding and Cutting (Published by National Safety Council, Chicago, Ill.).

struction in welding practice and related subjects as prescr bed in Sections IV and V. His duties shall include:

1. Planning instruction in accordance with course outline.
2. Following the four basic steps of instruction as follows:

given in Appendix A.

* Except where noted, this material is published by the AMERICAN WELDING SOCIETY

† Code of Minimum Requirements for Instruction of Welding Operators, Part B-1—Oxyacetylene Welding of Steel-Aircraft.
† Safe Practices Pamphlet No. 23—Gas Welding and Cutting (Published by National Safety Council, Chicago, Ill.).
Safe Practices for Installation and Operation of Oxy-Acetylene Welding and Cutting Equipment (published by International Acetylene Association, New York).
† Definitions of Welding Terms and Master Chart of Welding Processes.
Recommended Practices for Inspection of Fusion Welding.
Standard Qualification Procedure.
Welding Symbols and Instructions for Their Use.
Standard Methods for Mechanical Testing of Welds.
Recommended Procedure to Be Followed in Preparing for Welding or Cutting Certain Types of Containers Which Have Held Combustibles.
Handbook for Welding and Cutting Operators (published by International Acetylene Association, New York).

An annotated selected bibliography of publications relating to gas-welding instruction is given in Appendix H. It is recommended that the school library contain as many as possible of these publications.

SECTION III—QUALIFICATIONS AND DUTIES OF INSTRUCTOR

301. Qualifications of Instructors

(*a*) Each instructor giving any portion of the instruction prescribed in Section IV—Instruction in Welding Practice, shall possess the following qualifications:

1. A minimum of three years' total experience as a welding operator or welding supervisor, at least two years of which shall have been spent as a manual gas welding operator.
2. Proven ability to pass all of the tests prescribed for trainee in Sections IV and VI of this Code.
3. A practical knowledge of the physical properties of the materials, and the welding processes used in aircraft.
4. Thorough familiarity with the topics in related information covered in Section V.

(*b*) Each instructor giving any portion of the instruction prescribed in Section V—Instruction in Related Information, shall possess the following qualifications:

1. A minimum of three years' experience as a welding operator, welding supervisor or welding engineer.
2. A practical knowledge of elementary metallurgical principles involved in the welding of steel.
3. Thorough familiarity with the topics in related information covered in Section V.

302. Duties of Instructors

The instructor shall be charged with the responsibility of giving the instruction in welding practice and related subjects as prescribed in Sections IV and V. His duties shall include:

1. Planning instruction in accordance with course outline.
2. Following the four basic steps of instruction as follows:
   (*a*) Preparing the trainee for new instruction.
   (*b*) Using appropriate methods in presenting new instruction. (Demonstration, illustration, explanation, discussion, etc.)
   (*c*) Providing proper supervision and criticism as the trainee applies his new knowledge and skill.
   (*d*) Supervising and checking tests assigned to trainees.
3. Instructing the trainee to work safely, emphasizing the school's safety regulations (proper work clothing, etc.).
4. Distributing his instructional time equitably among all trainees.
5. Observing acceptable shop management practices.
   (*a*) Care, control and conservation of materials and equipment.
   (*b*) Shop cleanliness and orderliness.
   (*c*) Control of trainee discipline and trainee activities.
6. Keeping attendance records and recording trainees' progress.
7. Maintaining acceptable instructor-trainee relationships.
8. Adhering to school policies and procedures.
9. Improving instructional skills and techniques.

† These books are specifically recommended for study by the trainee.

SECTION IV—INSTRUCTION IN WELDING PRACTICE

401. General

(*a*) In view of the established military standards for aircraft welding operators, this Code has been arranged to provide training for the various grades recognized. Therefore:

1. Successful completion of the work in Course I, Articles 402 through 411, and the required related instruction together with successful completion of Tests 1 and 2 in Section VI prepares a trainee for the work of a Class B operator.

2. For operators who have successfully completed Course I preparing Class B operators, or those who have passed the Class B tests under competent supervision and inspection, Course II, Articles 412 through 417, and the required related instruction together with successful completion of Tests 3 and 4 in Section VI prepares a trainee for the work of a Class A operator.

(*b*) Instruction in welding practice shall be given by means of a series of exercises which shall conform at least to the minimum requirements prescribed in this section. The exercises shall be performed on steel sheet, tubing or plate, as appropriate for each individual exercise. The steel shall be reasonably free from rust, and free from paint, scale and other defects which adversely affect welding. For the execution of any exercise the trainee shall have a welding station for his exclusive use.

(*c*) After completing each group of exercises the trainee shall be required to pass the check tests prescribed herein, designed to demonstrate whether he has acquired a satisfactory degree of skill in the techniques covered by that group of exercises.

(*d*) In the check tests, frequent use is made of a modified guided-root-bend test, which shall be performed as follows: The welded joint as shown in Fig. 7 shall be bent in a jig having the working contour shown in Fig. 8, and otherwise substantially in accordance with that figure. Any convenient means may be used for moving the plunger member with relation to the die member. The specimen shall be placed on the die member of the jig with the weld at midspan and with the root of the weld directed toward the gap. The two members of the jig shall be forced together until the curvature of the specimen conforms generally to a U-shape. The specimen shall then be removed from the jig and its convex surface examined for the appearance of cracks or other open defects. Any specimen in which a crack or other open defect is present in the weld or within the zone of fusion after bending, exceeding $^1/_8$ in. measured in any direction, shall be considered as having failed.

(*e*) Most of the exercises required in this course involve making welds in sheet or thin plate, which, if defective, after testing as described in (*d*) above may readily be broken apart to permit examination of the weld for the cause of failure. It is therefore recommended that this practice be followed wherever practicable, immediately after each weld is completed and has been cooled in still air, so that the trainee can see the results of his previous work before proceeding to make the next weld.

COURSE I

402. Exercises—Group A—Setting Up and Operation of Equipment

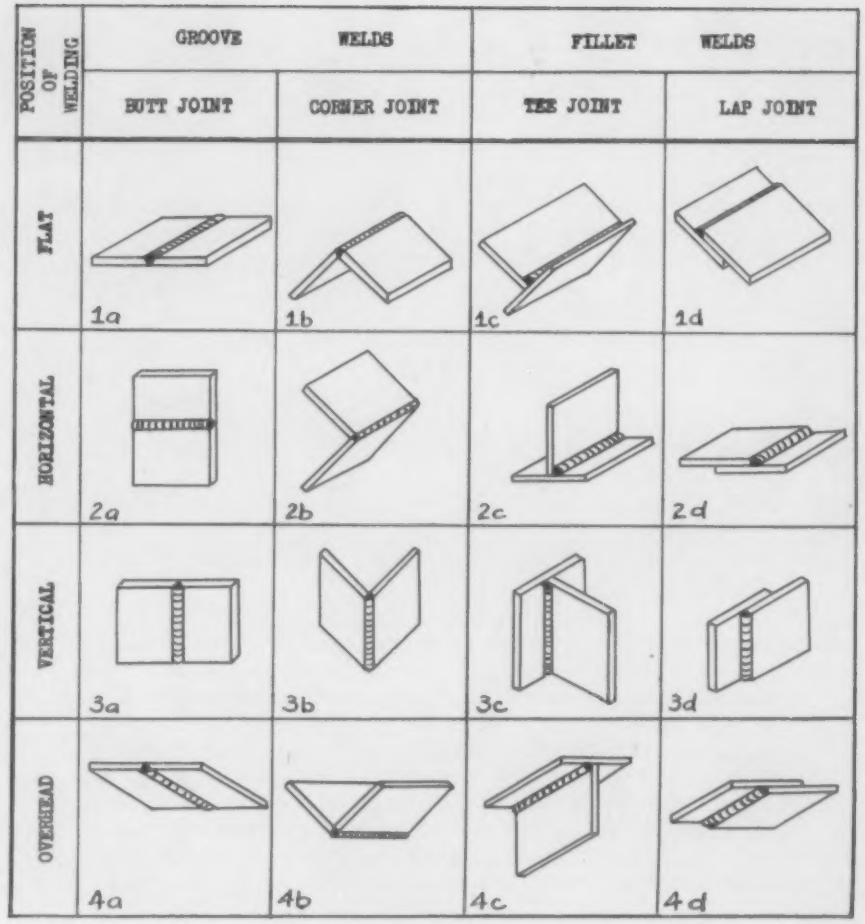
The exercises in Group A shall be designed to instruct the trainee in the proper methods of operating oxyacetylene welding equipment. The exercises shall include setting up the equipment, lighting the torch, adjusting the flame, shutting off the torch, and dismantling the equipment. The exercises shall be designed specifically to make the trainee aware of the necessity for observing the proper safety precautions at all times.

403. Check Tests on Exercises in Group A

The trainee shall be required to demonstrate a complete knowledge of the proper methods of operating oxyacetylene welding equipment, in the course of which he shall prove his ability to perform the following operations according to recommended safe practices:

(*a*) Set up the equipment.
(*b*) Adjust gas pressures.
(*c*) Light the torch.
(*d*) Adjust for a reducing flame.
(*e*) Adjust for a neutral flame.
(*f*) Adjust for an oxidizing flame.
(*g*) Shut off the torch.
(*h*) Dismantle the equipment.

The trainee shall be required to perform these operations to the satisfaction of the instructor.



Figs. 1-4—Illustrations of Positions for Welding Plate

404. Exercises—Group B—Corner Joints in Sheet

The exercises in Group B shall be designed to instruct the trainee in the technique of making bead welds in corner joints on $^1/_{16}$-in. and $^1/_8$-in. sheet,

the under side of the joint and no evidence of lack of fusion or other defects in the weld.

(*b*) *Hammer Test*—The joint shall withstand the hammer test without revealing a crack or other open defect (including lack of fusion) exceeding

tion of the instructor.

404. Exercises—Group B—Corner Joints in Sheet

The exercises in Group B shall be designed to instruct the trainee in the technique of making bead welds in corner joints on $^1/_{16}$-in. and $^1/_8$-in. sheet, in the flat position. The following exercises shall be included in this group:

(*a*) Making bead welds without filler metal.
(*b*) Making bead welds with filler metal.
(*c*) Making corner joints in $^1/_{16}$-in. sheet.
(*d*) Making corner joints in $^1/_8$-in. sheet.

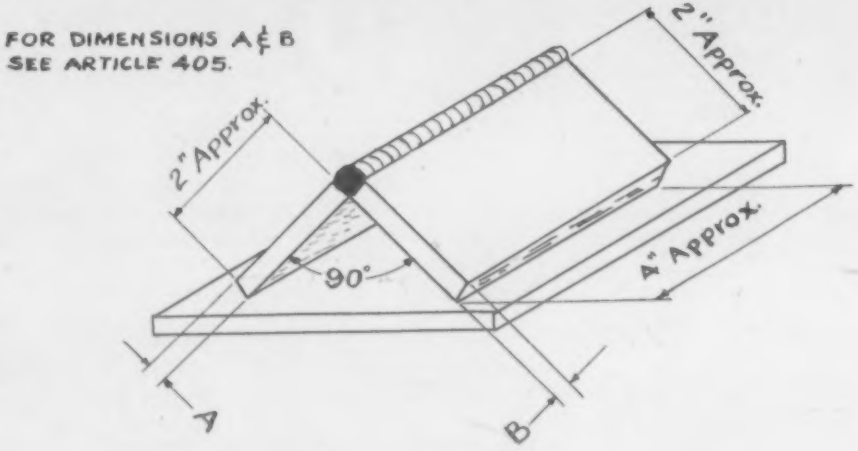


Fig. 5—Corner Joint

405. Check Tests on Exercises in Group B

The trainee shall be required to make two specimen welds conforming to the requirements stated in the following table:

Specimen Number	Joint Preparation	Position of Welding	Procedure of Welding
1	As illustrated in Fig. 5, with dimensions A and B both $^1/_{16}$ in.	Flat, as illustrated in Fig. 1*b*	Weld to be made with a $^1/_{16}$-in. welding rod, using forehand technique
2	As illustrated in Fig. 5, with dimensions A and B both $^1/_8$ in.	Flat, as illustrated in Fig. 1*b*	Weld to be made with a $^1/_{16}$-in. welding rod, using forehand technique

The welds shall be inspected visually for appearance and then tested by hammering the joint flat as shown in Fig. 6. Each weld shall meet the following requirements:

(*a*) *Appearance*—The exposed face of the weld shall be reasonably smooth and regular, and the weld reinforcement shall be a minimum of 25 percent of the thickness of the base metal. There shall be no "icicles" on the under side of the joint and no evidence of lack of fusion or other defects in the weld.

(*b*) *Hammer Test*—The joint shall withstand the hammer test without revealing a crack or other open defect (including lack of fusion) exceeding $^1/_8$ in. measured in any direction.

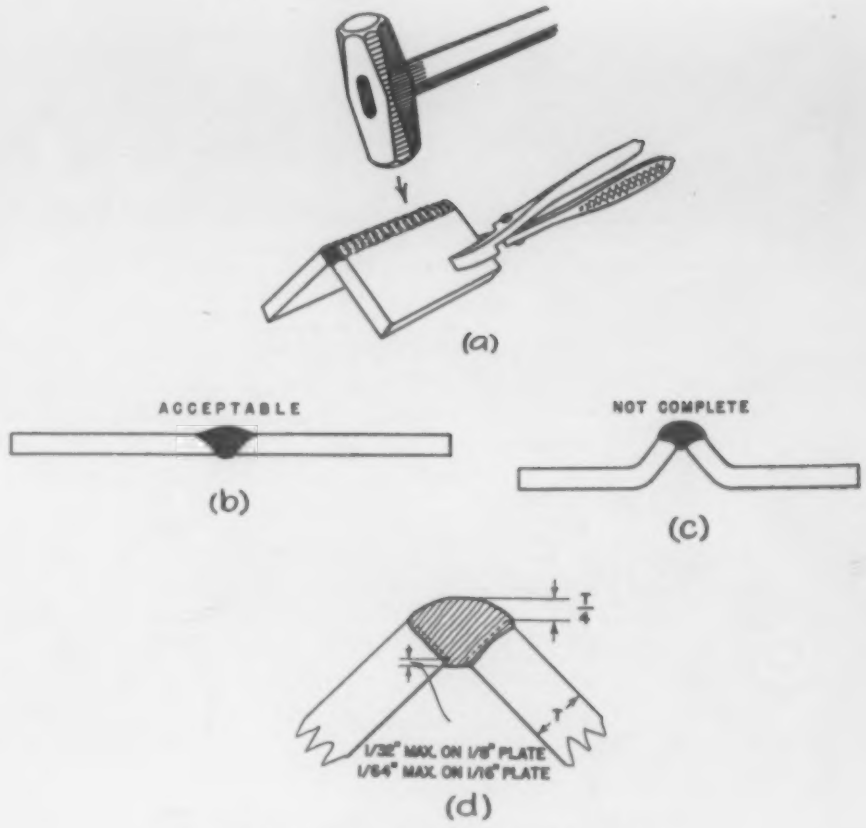


Fig. 6—Hammer Test for Corner Joint

406. Exercises—Group C—Butt Joints in Sheet

The exercises in Group C shall be designed to instruct the trainee in the technique of making butt joints in $^1/_{16}$-in. and $^1/_8$-in. sheet, in the flat, vertical and overhead positions. The following exercises shall be included in this group, and those marked with an asterisk shall be performed by both forehand and backhand techniques.

(*a*) Making butt joints in $^1/_{16}$-in. sheet in the flat position.
*(*b*) Making butt joints in $^1/_8$-in. sheet in the flat position.
(*c*) Making butt joints in $^1/_{16}$-in. sheet in the vertical position.

*(d) Making butt joints in 1/8-in. sheet in the vertical position.
(e) Making butt joints in 1/16-in sheet in the overhead position.
*(f) Making butt joints in 1/8-in sheet in the overhead position.

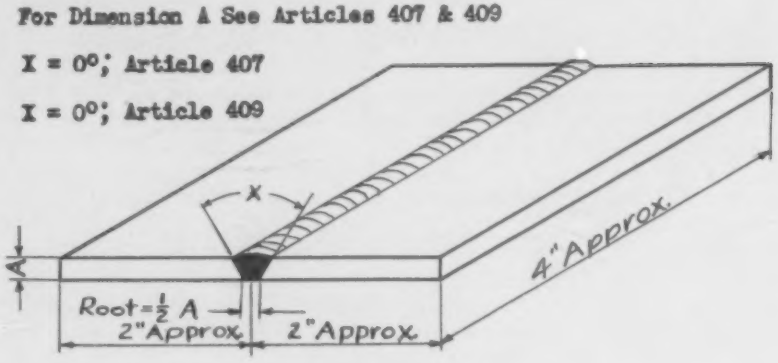


Fig. 7—Butt Joint

407. Check Tests on Exercises in Group C

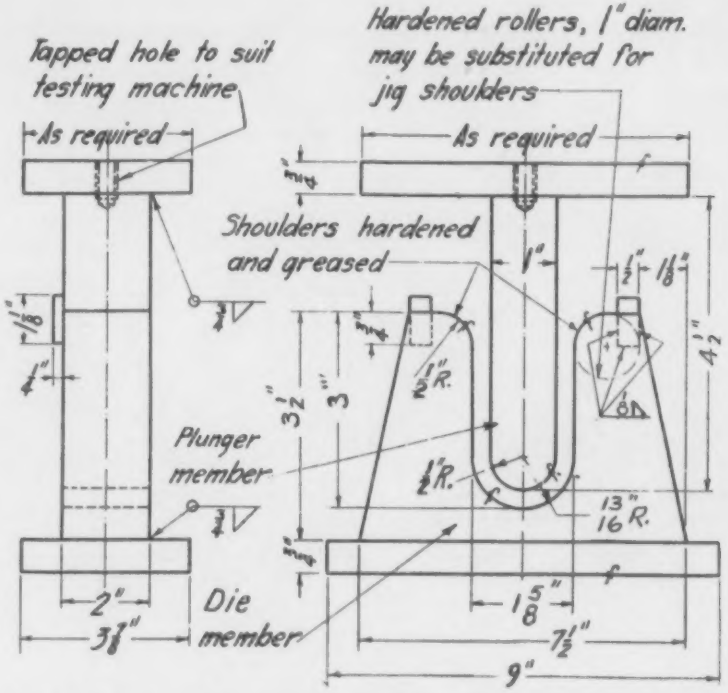
The trainee shall be required to make six specimen welds conforming to the requirements stated in the following table:

Specimen Number	Joint Preparation	Position of Welding	Procedure of Welding
3 and 4	As illustrated in Fig. 7 with dimension A = 1/8 in.	Flat, as illustrated in Fig. 1a	Weld to be made with a 1/16-in. welding rod, using forehand technique for specimen No. 3 and backhand technique for specimen No. 4
5 and 6	As illustrated in Fig. 7 with dimension A = 1/8 in.	Vertical, as illustrated in Fig. 3a	Welds to be made with a 1/16-in. welding rod, using forehand technique for specimen No. 5 and backhand technique for specimen No. 6
7 and 8	As illustrated in Fig. 7 with dimension A = 1/8 in.	Overhead, as illustrated in Fig. 4a	Welds to be made with a 1/16-in. welding rod, using forehand technique for specimen No. 7 and backhand technique for specimen No. 8

The welds shall be inspected visually for appearance and then given the guided-root-bend test (see Article 401 *d*). Each weld shall meet the following requirements:

(*a*) *Appearance*—The exposed face of the weld shall be reasonably smooth and regular, and the weld reinforcement shall be a minimum of 25 percent of the thickness of the base metal. There shall be no "icicles" on the under side of the joint and no evidence of overlapping, undercutting, lack of fusion, or other defects in the weld.

(*b*) *Bend Test*—The joint shall successfully pass the guided-root-bend test as prescribed in Article 401 (*d*).



NOTE: This is not the standard guided-bend test jig, but a modified jig designed to test sheet and plate up to 1/4 in. thick.

Fig. 8—Guided-Bend Test Jig

408. Exercises—Group D—Butt Joints in Heavy Sheet

The exercises in Group D shall be designed to instruct the trainee in the technique of making butt joints in 3/16-in. and 1/4-in. sheet, in the flat and vertical positions. The following exercises shall be included in this group and shall be made employing both the forehand and backhand techniques.

(*a*) Making butt joints in 3/16-in or 1/4-in. sheet in the flat position.
(*b*) Making butt joints in 3/16-in or 1/8-in sheet in the vertical position.

409. Check Tests on Exercises in Group D

The trainee shall be required to make two specimen welds conforming to the requirements stated in the following table:

Specimen Number	Joint Preparation	Position of Welding	Procedure of Welding
9 and 10	As illustrated in Fig. 7	Flat, as illustrated	Weld to be made with a 1/8-

(*d*) Making butt joints in tubing in the vertical fixed position at eye level (see Fig. 10*d*).

Specimen Number	Joint Preparation	Position of Welding	Procedure of Welding
9 and 10	As illustrated in Fig. 7 with dimension A = 1/4 in.	Flat, as illustrated in Fig. 1*a*	Weld to be made with a 1/8-in. welding rod using forehand technique for specimen No. 9 and backhand technique for specimen No. 10
11 and 12	As illustrated in Fig. 7 with dimension A = 1/4 in.	Vertical, as illustrated in Fig. 3*a*	Weld to be made with a 1/8-in. welding rod, using the forehand tecnnique for specimen No. 11 and backhand technique for specimen No. 12

The welds shall be inspected visually for appearance and then given the guided root-bend test (see Article 401 *d*). Each weld shall meet the following requirements:

(*a*) *Appearance*—The exposed face of the weld shall be reasonably smooth and regular, and the weld reinforcement shall be a minimum of 25 percent of the thickness of the base metal. There shall be no "icicles" on the under side of the joint and no evidence of overlapping, undercutting, lack of fusion, or other defects in the weld.

(*b*) *Bend Test*—The joint shall successfully pass the guided root-bend test as prescribed in Article 401 (*d*).

410. Exercises—Group E—Welding of Tubing

The exercises in Group E shall be designed to instruct the trainee in the technique of making joints in tubing. All of the exercises shall be performed with tubing of 1-in. nominal diameter with a wall thickness not greater than 0.070 in. The following exercises shall be included in this group:

(*a*) Making butt joints in tubing in the horizontal rolled position at bench level (see Fig. 10*a*).

(*b*) Making butt joints in tubing in the vertical position at bench level (may be rotated) (see Fig. 10*b*).

(*c*) Making butt joints in tubing in the horizontal fixed position at eye level (see Fig. 10*c*).

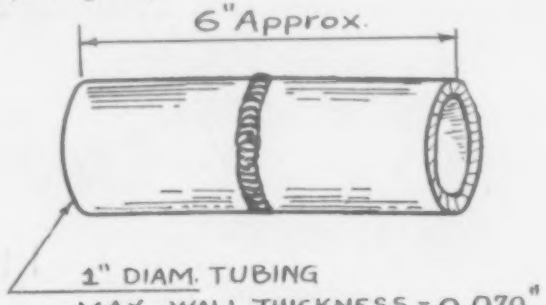


Fig. 9—Butt Joint in Tubing

(*d*) Making butt joints in tubing in the vertical fixed position at eye level (see Fig. 10*d*).

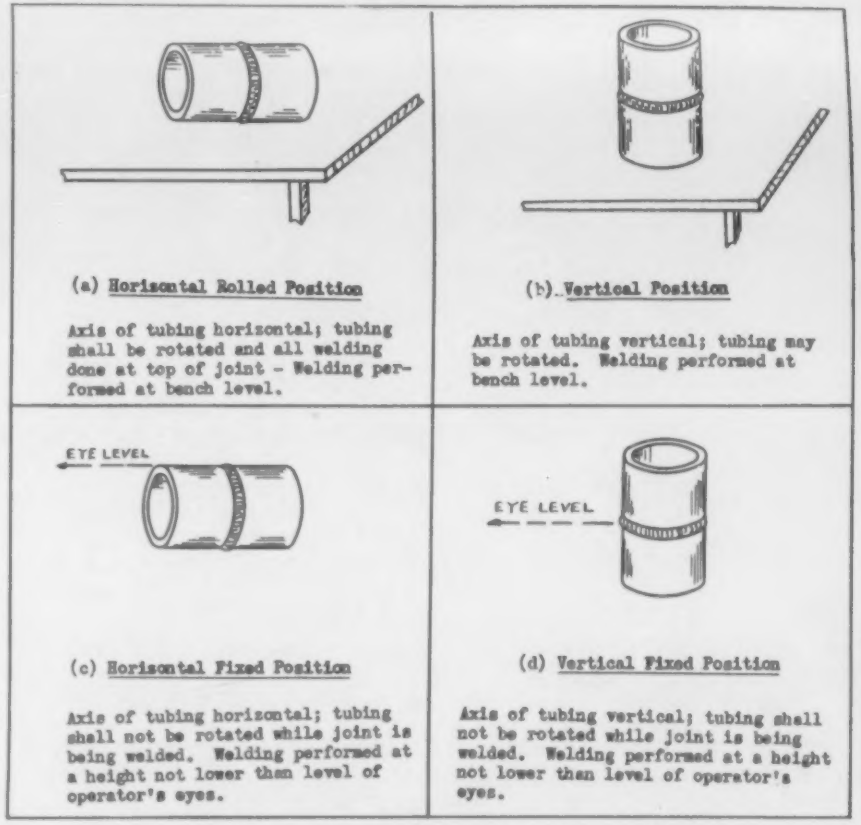

(a) Horizontal Rolled Position
Axis of tubing horizontal; tubing shall be rotated and all welding done at top of joint - Welding performed at bench level.
(b) Vertical Position
Axis of tubing vertical; tubing may be rotated. Welding performed at bench level.
EYE LEVEL
(c) Horizontal Fixed Position
Axis of tubing horizontal; tubing shall not be rotated while joint is being welded. Welding performed at a height not lower than level of operator's eyes.
EYE LEVEL
(d) Vertical Fixed Position
Axis of tubing vertical; tubing shall not be rotated while joint is being welded. Welding performed at a height not lower than level of operator's eyes.

Fig. 10—Illustrations of Positions for Welding Tubing

411. Check Tests on Exercises in Group E

The trainee shall be required to make two specimen welds conforming to the requirements stated in the following table:

Specimen Number	Joint Preparation	Position of Welding	Procedure of Welding
13	As illustrated in Fig. 9	Horizontal fixed position, as illustrated in Fig. 10*c*, with the weld located not lower than the trainee's eyes	Weld to be made with a 1/16-in. welding rod
14	As illustrated in Fig. 9	Vertical fixed position, as illustrated in Fig. 10*d*, with the weld located not lower than the trainee's eyes	Weld to be made with a 1/16-in. welding rod

The welds shall be inspected visually for appearance, after which each specimen shall be given an etch test as follows: The specimen shall be cut in two in a manner that will reveal a complete cross section of the welded joint. Either half shall be polished and etched with a 10–20% aqueous solution of ammonium persulphate at room temperature for a sufficient length of time to bring out the boundaries between the weld metal and the base metal. The etched section shall then be examined for penetration, extent of fusion, and porosity of the weld metal. For a further discussion on etching see Appendix B.

Each weld shall meet the following requirements:

(*a*) *Appearance*—The exposed face of the weld shall be reasonably smooth and regular, and the weld reinforcement shall be a minimum of 25 percent of the thickness of the base metal. There shall be no evidence of overlapping, undercutting, lack of fusion, or other defects in the weld, and there shall be no "icicles" on the inside of the tubing.

(*b*) *Etch Test*—The weld shall exhibit complete fusion between the weld metal and the base metal and complete penetration to the root of the weld. The weld shall contain no gas pockets, oxide particles, or slag inclusions.

COURSE II

412. Exercises—Group F—Lap Joints in Sheet

The exercises in Group F shall be designed to instruct the trainee in the technique of making lap joints in $^1/_{16}$-in. and $^1/_8$-in. sheet, in the horizontal, vertical and overhead positions, and in making similar joints in two sheets of different thickness. The following exercises shall be included in this group, and those marked with an asterisk shall be performed by both the forehand and backhand techniques:

(*a*) Making lap joints in $^1/_{16}$-in. sheet in the horizontal position.
*(*b*) Making lap joints in $^1/_8$-in. sheet in the horizontal position.
(*c*) Making lap joints in $^1/_{16}$-in. sheet in the vertical position.
*(*d*) Making lap joints in $^1/_8$-in. sheet in the vertical position.
(*e*) Making lap joints in $^1/_{16}$-in. sheet in the overhead position.
(*f*) Making lap joints in $^1/_8$-in. sheet in the overhead position.
(*g*) Making lap joints in the horizontal position, in which one sheet is $^1/_{16}$ in. thick and the other sheet is $^1/_8$ in. or over in thickness.
(*h*) Making lap joints in the vertical position, in which one sheet is $^1/_{16}$ in. thick and the other sheet is $^1/_8$ in. or over in thickness.

413. Check Tests on Exercises in Group F

The trainee shall be required to make two specimen welds conforming to the requirements stated in the following table:

Specimen Number	Joint Preparation	Position of Welding	Procedure or Welding
15	As illustrated in Fig. 11 with dimension A = $^1/_8$ in. and dimension B = $^1/_{16}$ in.	Horizontal, as illustrated in Fig. 2*d*	Weld to be made with a $^1/_{16}$-in. welding rod (forehand technique)
16	As illustrated in Fig. 11 with dimension A = $^1/_8$ in. and dimension B = $^1/_{16}$ in.	Vertical, as illustrated in Fig. 3*d*	Weld to be made with a $^1/_{16}$-in. welding rod (forehand technique)

The welds shall be inspected visually for appearance and then tested by hammering the joint until it assumes a T-shape, as illustrated in Fig. 12. Each weld shall meet the following requirements:

(*a*) *Appearance*—The exposed face of the weld shall be reasonably smooth and regular, and the weld reinforcement shall be neither insufficient nor excessive. There shall be no evidence of overlapping, undercutting, lack of fusion, or other defects in the weld.

(*b*) *Hammer Test*—The joint shall withstand the hammer test without cracking and shall reveal no evidence of lack of fusion at the root of the weld.

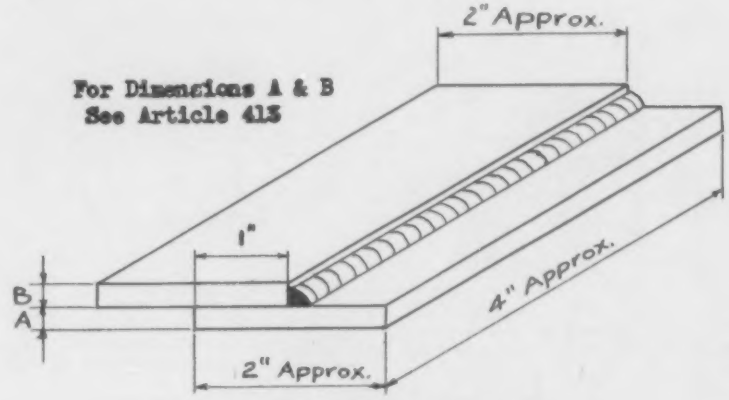


Fig. 11—Lap Joint

414. Exercises—Group G—Tee Joints in Sheet

The exercises in Group G shall be designed to instruct the trainee in the technique of making tee joints in $^1/_{16}$-in. and $^1/_8$-in. sheet, in the horizontal and vertical positions, and in making similar joints in two sheets of different thickness. The following exercises shall be included in this group, and those marked with an asterisk shall be performed by both the forehand and backhand techniques:

(*a*) Making tee joints in $^1/_{16}$-in. sheet in the horizontal position.
*(*b*) Making tee joints in $^1/_8$-in. sheet in the horizontal position.
(*c*) Making tee joints in $^1/_{16}$-in. sheet in the vertical position.
*(*d*) Making tee joints in $^1/_8$-in. sheet in the vertical position.

(*e*) Making tee joints in the horizontal position, in which the through member is $^1/_4$ in. thick and the butting member is $^1/_{16}$ in. thick.
(*f*) Making tee joints in the vertical position, in which the through

(*e*) Making tee joints in the horizontal position, in which the through member is $^1/_4$ in. thick and the butting member is $^1/_{16}$ in. thick.
(*f*) Making tee joints in the vertical position, in which the through member is $^1/_4$ in. thick and the butting member is $^1/_{16}$ in. thick.

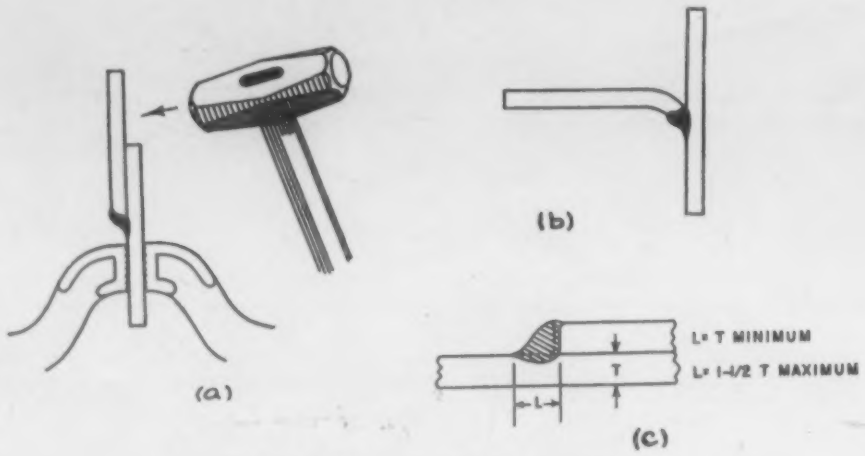


Fig. 12—Hammer Test for Lap Joint

415. Check Tests on Exercises in Group G

The trainee shall be required to make two specimen welds conforming to the requirements stated in the following table:

Specimen Number	Joint Preparation	Position of Welding	Procedure of Welding
17	As illustrated in Fig. 13 with dimension A = $^1/_{16}$ in. and dimension B = $^1/_4$ in. .	Horizontal, as illustrated in Fig. 2*c*	Weld to be made with a $^1/_{16}$-in. welding rod (forehand technique)
18	As illustrated in Fig. 13 with dimension A = $^1/_{16}$ in. and dimension B = $^1/_4$ in.	Horizontal, as illustrated in Fig. 2*c*	Weld to be made with a $^1/_{16}$-in. welding rod (backhand technique)

The welds shall be inspected visually for appearance and then tested by hammering the joint flat as shown in Fig. 14. Each weld shall meet the following requirements:

(*a*) *Appearance*—The exposed face of the weld shall be reasonably smooth and regular, and the weld reinforcement shall be neither insufficient nor excessive. There shall be no evidence of overlapping, undercutting, lack of fusion, or other defects in the weld.

(*b*) *Hammer Test*—The joint shall withstand the hammer test without cracking and shall reveal no evidence of lack of fusion at the root of the weld.

(*c*) Making tee joints in $^1/_{16}$-in. sheet in the vertical position.
*(*d*) Making tee joints in $^1/_8$-in. sheet in the vertical position.

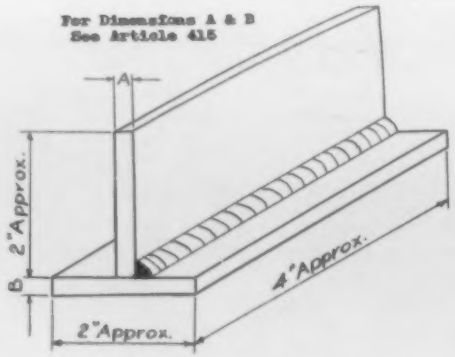


Fig. 13—Tee Joint

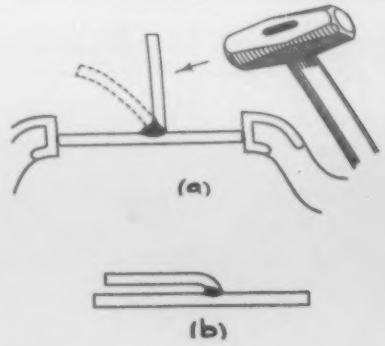


Fig. 14—Hammer Test for Tee Joint

416. Exercises—Group H—Tubes to Sheets or Plates

The exercises in Group H shall be designed to instruct the trainee in the technique of making joints between tubing and sheets or plates. All of the exercises shall be performed with tubing of 1-in. nominal diameter, with a wall thickness not greater than 0.070 in. The following exercises shall be included in this group.

(*a*) Making joints in the flat or horizontal position as shown in Fig. 15 with dimension A = $^1/_{16}$ in.
(*b*) Making joints in the flat or horizontal position as shown in Fig. 15 with dimension A = $^1/_8$ in.
(*c*) Making joints in the flat or horizontal position as shown in Fig. 15 with dimension A = $^3/_{16}$ in.
(*d*) Making joints in the flat or horizontal position as shown in Fig. 15 with dimension A = $^1/_4$ in.
(*e*) Making joints in the vertical position as shown in Fig. 16.

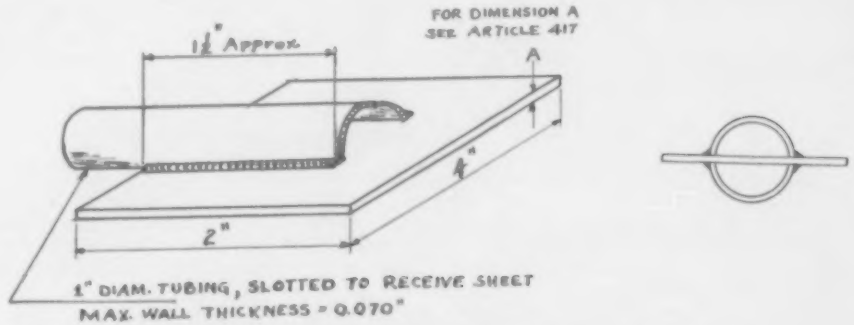


Fig. 15—Sheet to Tubing Joint Flat or Horizontal Position

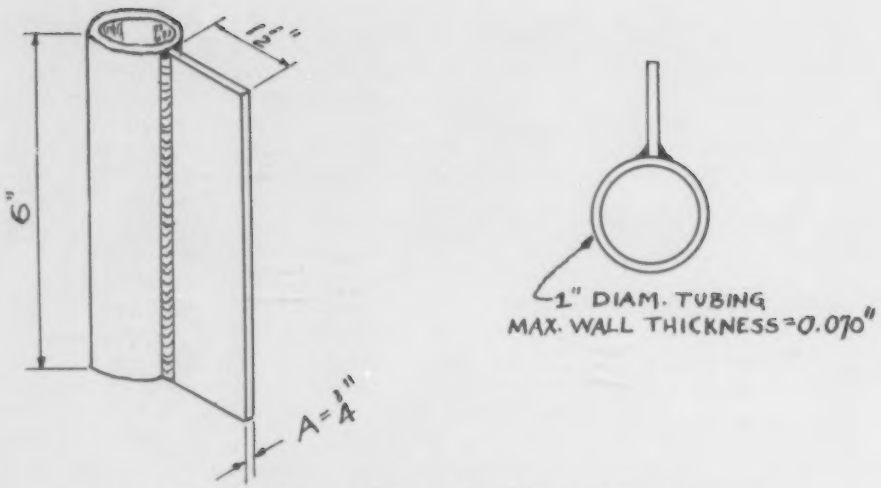


Fig. 16—Sheet to Tubing Joint, Vertical Position

417. Check Tests on Exercises in Group H

The trainee shall be required to make two specimen welds conforming to the requirements stated in the following table:

Specimen Number	Joint Preparation	Position of Welding	Procedure of Welding
19	As illustrated in Fig. 15 with dimension A = 1/4 in.	Flat or horizontal as illustrated in Fig. 1*c* or 2*c*	Welds to be made with a 1/8-in. welding rod
20	As illustrated in Fig. 16	Vertical as illustrated in Fig. 3*c*	Welds to be made with a 1/8-in. welding rod

The welds shall be inspected visually for appearance and then cut across the weld and etched. For a discussion on etching see Appendix B.

(*a*) *Appearance*—The exposed face of the weld shall be reasonably smooth and regular, and the weld reinforcement shall be neither insufficient nor excessive. There shall be no "icicles" on the under side of the joint and no evidence of overlapping, undercutting, lack of fusion, or other defects in the weld.

(*b*) *Etch Test*—The etched surface shall disclose complete penetration at the root of the weld and a minimum depth of fusion of 25 percent into both members.

SECTION V—INSTRUCTION IN RELATED INFORMATION

501. General

Instruction in related information shall be given as prescribed in Articles 502 through 508.

The instructor shall be responsible for seeing that each trainee acquires a satisfactory knowledge of the subjects covered in this section. This related information may be given in a classroom or at the welding station when the problems arise as indicated in the following Articles. (Appendix H lists publications on welding theory that contain detail information on the subjects listed in this section.)

502. Topic A—Safety in Welding

The instruction in this subject shall be designed to make the trainee aware of the necessity for observing safety precautions under the three following general headings.

(*a*) *Protection of Person*—i.e., proper shoes, clothing, goggles, adequate ventilation, etc.

(*b*) *Protection of Property*—i.e., safeguarding combustible material, protection from sparks and hot slag, availability of fire protection equipment, etc.

(*c*) *Protection and Care of Equipment*—i.e., proper use of compressed gas cylinders, correct use of equipment, avoidance of contact of oil or grease with oxygen under pressure, etc.

This subject shall be given, preferably in a classroom, before the trainees are permitted to use any oxyacetylene equipment, and is required for Courses I and II.

503. Topic B—Welding and Cutting Equipment

The instruction in this subject shall be designed to instruct the trainee in the construction and adjustment of torches, regulators, cylinders and related equipment, and shall be given, preferably in a classroom, before the trainee is permitted to use any oxyacetylene equipment. Trainees shall be taught the proper method of cleaning welding tips and to perform other minor adjustments, but shall be instructed not to attempt repairs. This topic is required for Courses I and II.

504. Topic C—Weld Characteristics

The instruction in this subject shall be designed to familiarize the trainee with the characteristics of good welds. The discussion shall include the following topics:

(*a*) Soundness.
(*b*) Fusion.
(*c*) Penetration.
(*d*) Weld contours and dimensions.

The instruction on this topic shall be so organized that the details appropriate to each group of exercises prescribed in Section IV shall be given before the trainee undertakes the work of that Section. This topic is required for Courses I and II.

505. Topic D—Inspection and Testing of Welds

The instruction in this subject shall be designed to acquaint the trainees

SECTION VI—FINAL TESTS

601. General*

502 through 508.

505. Topic D—Inspection and Testing of Welds

The instruction in this subject shall be designed to acquaint the trainees with the more common methods of weld inspection and testing, and shall be given in the form of a discussion of the trainee's welds before and after testing. The instructor shall point out such difficulties as may have caused failure in the specimen. In the over-all study of this topic, description of the following methods shall be covered.

(*a*) Visual inspection and gaging.
(*b*) Bend testing.
(*c*) Tensile testing.
(*d*) Pressure tests.
(*e*) Magnetic particle inspection.
(*f*) Radiographic inspection.

It is recommended that the instruction in weld inspection be based on the AMERICAN WELDING SOCIETY'S "Recommended Practices for Inspection of Fusion Welding," and that the instruction in weld testing be based on the AMERICAN WELDING SOCIETY'S "Standard Methods for Mechanical Testing of Welds" and "Standard Qualification Procedure." Methods (*a*), (*b*) and (*c*) are required in Course I. Methods (*d*), (*e*) and (*f*) are required in Course II.

506. Topic E—Welding Processes and Welding Terms

The instruction in these subjects shall be designed to acquaint the trainee with the principal welding processes and the more important terms relating to oxyacetylene welding and cutting. The instruction in welding terms shall be based on the AMERICAN WELDING SOCIETY'S "Definitions of Welding Terms and Master Chart of Welding Processes." This topic shall be given preferably in a classroom, and shall be required for Courses I and II.

507. Topic F—Nature of Iron and Steel

The instruction in this subject shall be designed to give the trainee an elementary knowledge of the thermal and metallurgical factors involved in the welding of steel. The discussion shall include the chemical composition and mechanical properties of iron and steel, and the effects of expansion, contraction, shrinkage and warpage associated with welding. This topic shall be required for Course II and may be given in an abridged form in Course I.

508. Topic G—Occupational Requirements

The instruction in this topic shall be designed to acquaint the trainee with the work of the oxyacetylene welding operator in the aircraft industry. The discussion shall include a description of the duties of the Class B and Class A operators and the types of work encountered in each class. The qualification tests required for each class shall also be covered.

before the trainee undertakes the work of that Section. This topic is required for Courses I and II.

SECTION VI—FINAL TESTS

601. General*

The final tests prescribed in this section shall be conducted after the trainee has completed all the requirements prescribed in Sections IV and V of this Code for the course taken. The final tests for Course I shall consist of Test No. 1, Article 603, and Test No. 2, Article 604. The final tests for

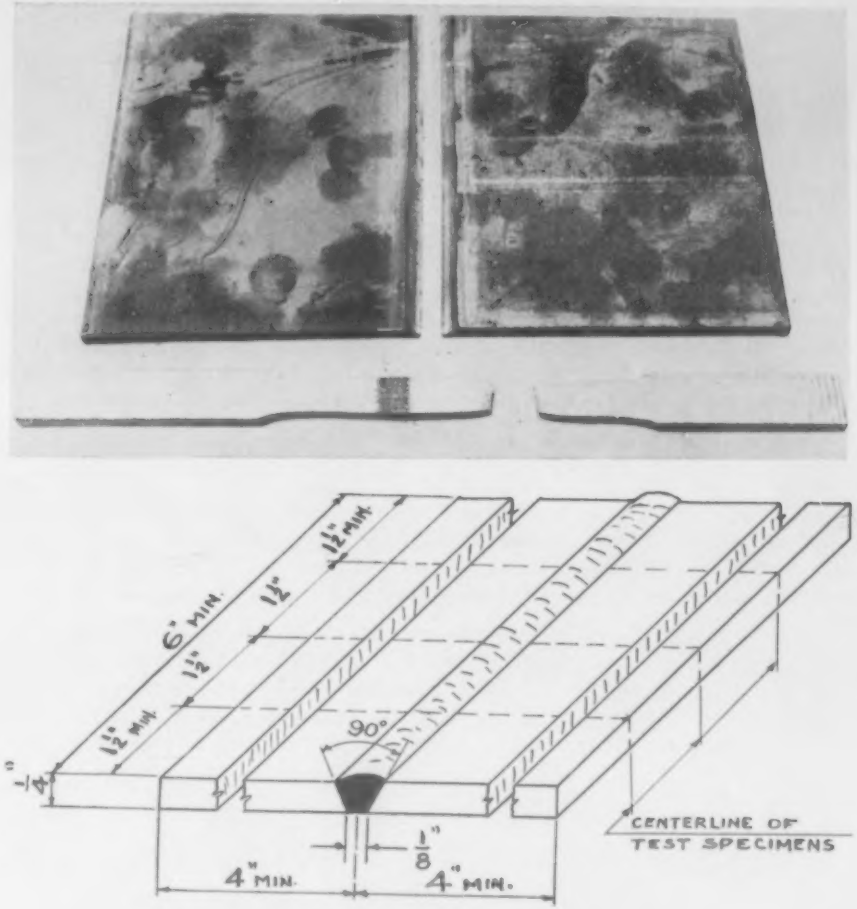


Fig. 17—Butt Joint in Plate (Test Joint No. 1)

* The final tests prescribed in this section conform to the present operator certification tests applicable to construction of military, naval and civil aircraft. The trainee should understand, however, that the successful passing of these tests does not qualify him as a welding operator for such work. Certification for aircraft work is possible only when these or other required tests are witnessed and certified to by a person officially authorized to act in this capacity. Success in passing these final tests, however, should indicate the trainee's ability to pass the official tests if given under similar conditions.

Course II shall consist of Test No. 3, Article 605, and Test No. 4, Article 606. No trainee shall be considered as having completed any of the several courses who has not fulfilled the respective requirements of this section.

Upon completion of the course and successful passage of the final tests prescribed for the course taken, the trainee shall receive a Record Card witnessing thereto as specified in Article 106.

602. Base Material and Filler Metal

The base material used for the final tests shall be plain carbon or alloy steel of the types approved for aircraft construction. The filler metal shall conform to the A.W.S.-A.S.T.M. Tentative Specifications for Iron and Steel Gas Welding Rods (Serial Designation A-251).

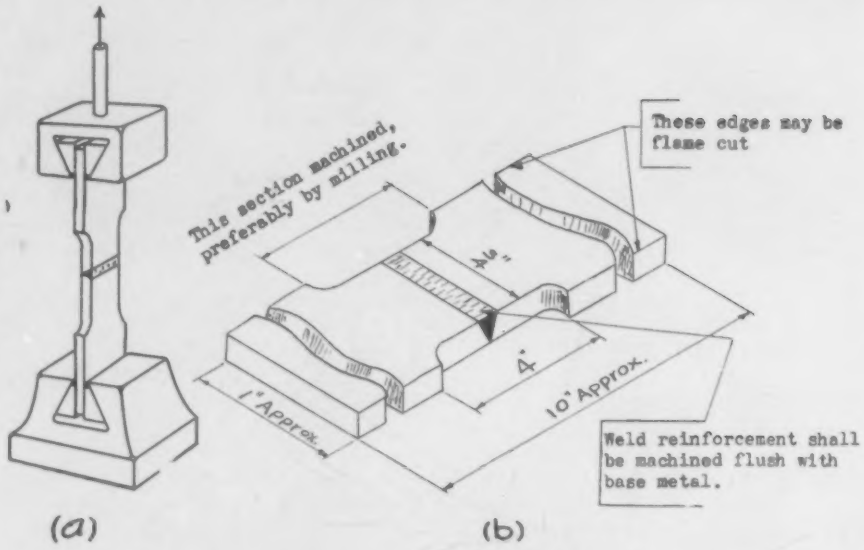


Fig. 18—Tension Test Specimen for Plate

603. Test No. 1—Butt Joint in Plate (Required for Course I)

A single vee groove welded butt joint conforming to the dimensions shown in Fig. 17 shall be made in the flat position. From the completed test, not less than three specimens shall be removed as shown in Fig. 17 and prepared for testing as shown in Fig. 18. A tensile test shall be made on each specimen, and the average strength for the three samples shall not be less than given in Table I. The strength of any individual specimen shall not be less than 90 percent of the average value given in Table I.

Table I—Tensile Strength of Weld Metal—Pounds per Square Inch

Carbon Content of Filler Rod	Carbon Steel Base Metal	Alloy Steel Base Metal
Up to 0.06, incl.	45,000	55,000
0.07–0.12	50,000	65,000
Over 0.12	55,000*	70,000*

* These values shall be used for alloy steel filler rod.

604. Test No. 2—Butt Joint in Tubing (Required for Course I)

A test joint conforming to the dimensions shown in Fig. 19 shall be welded in each of the following positions:

(*a*) Horizontal rolled position at bench level as illustrated in Fig. 10*a*
(*b*) Vertical position at bench level as illustrated in Fig. 10*b* (may be rotated).
(*c*) Horizontal fixed position at eye level as illustrated in Fig. 10*c*.
(*d*) Vertical fixed position at eye level as illustrated in Fig. 10*d*.

The joints shall be tested as tensile specimens with the reinforcement. The strength of the joint shall not be less than 50,000 pounds per square inch for plain carbon and 80,000 pounds per square inch for alloy steel, calculated on the area of the base metal.

605. Test No. 3—Double-Tee Joint (Cross) (Required for Course II)

A test joint conforming to the dimensions shown in Figs. 20*a* and 20*b* shall be welded in the vertical position, as illustrated in Fig. 3*c*, the pieces being so supported that there is clearance between the lower end of the test specimen and the jig, and prepared for testing as illustrated in Fig. 20*b*. The joint shall be tested in tension, as indicated in Fig. 20*a*. The joint shall develop not less than 10,000 pounds per inch of specimen width A as shown in Fig. 20*b* when the base metal is plain carbon steel, and 15,000 pounds per linear inch for alloy steel. The broken specimen shall be examined to determine whether or not the weld has been fused into the base metal in the corner.

606. Test No. 4—Cluster Joint of Sheet and Tubing (Required for Course II)

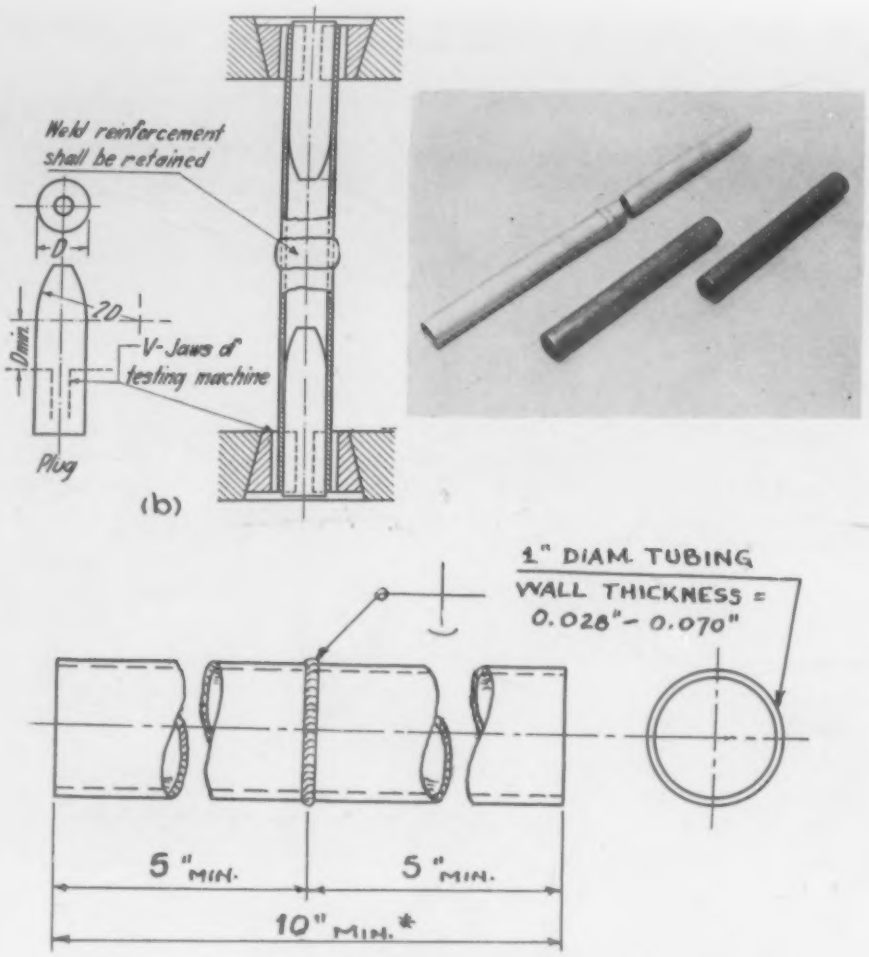
A test joint conforming to the dimensions shown in Fig. 21 shall be welded in the flat or horizontal position. The completed test joint shall be inspected visually for appearance, after which it shall be cut at Section AA as shown in Fig. 21, and either half shall be polished and etched with a suitable solution* to bring out the boundaries between the weld metal and the base metal. Each weld shall meet the following requirements:

(*a*) *Appearance*—The exposed face of the weld shall be reasonably smooth and regular, and the weld reinforcement shall be neither insufficient nor excessive. There shall be no evidence of overlapping, undercutting,

* A 10–20% aqueous solution of ammonium persulphate at room temperature is preferred for etching specimens in schools. Other methods of etching are covered in the A.W.S. pamphlet, "Standard Methods for Mechanical Testing of Welds." See also Appendix B.

Table I.

A.W.S. pamphlet, "Standard Methods for Mechanical Testing of Welds." See also Appendix B.



*Overall length may be reduced after welding to accommodate testing machine capacity by sawing equal lengths from each end of the specimen.

4 SPECIMENS REQD.

(a)

Fig. 19—Butt Joint in Tubing (Test Joint No. 2)

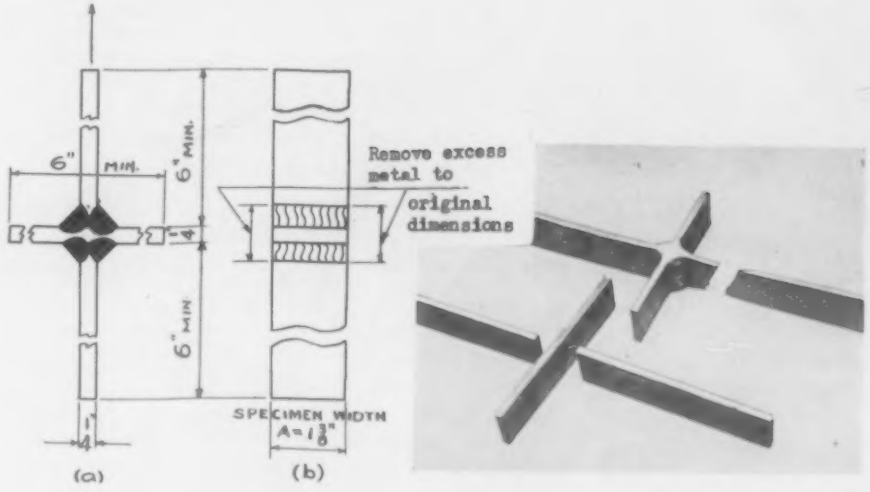
the base metal. Each weld shall meet the following requirements:

(*a*) *Appearance*—The exposed face of the weld shall be reasonably smooth and regular, and the weld reinforcement shall be neither insufficient nor excessive. There shall be no evidence of overlapping, undercutting, lack of fusion, or other defects in the weld. Further, there shall be no "icicles" on the inside of the tubes.

(*b*) *Etch Test*—The weld shall exhibit complete fusion between the weld metal and the base metal and complete penetration to the root of the weld. The weld shall contain no gas pockets, oxide particles or slag inclusions. Penetration between 25 and 40 percent below the surface of the base metal is desired in the case of materials $^1/_8$ in. or thicker. The penetration may be greater than this for thinner materials.

607. Retests

In case the trainee fails to pass one or more of the tests, a retest may be allowed at the discretion of the instructor and shall consist of two test welds of each type and each position on which he failed, each of which shall meet all the requirements prescribed for such welds.



2 SPECIMENS REQD.

Fig. 20—Double-Tee Joint (Cross) (Test Joint No. 3)

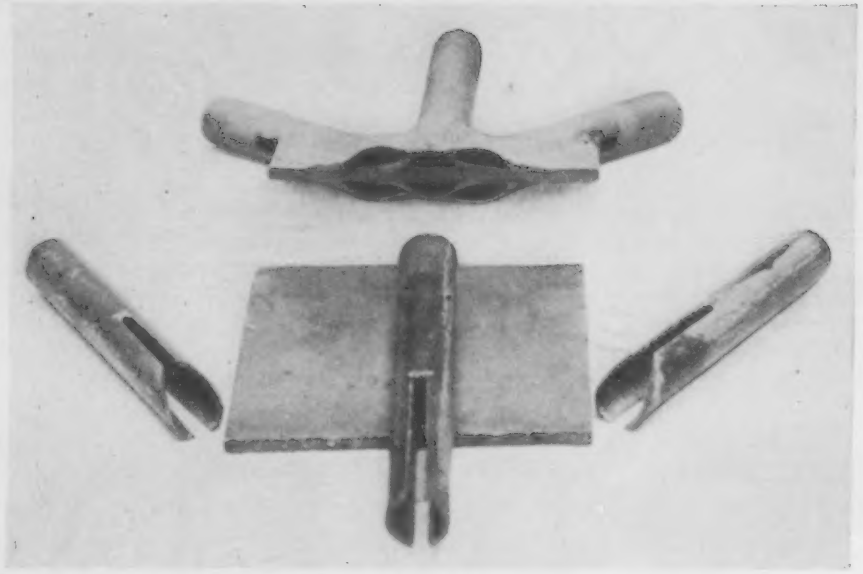


Fig. 21—Cluster Joint of Sheet and Tubing (Test Joint No. 4)

APPENDIX A

Suggested Accessory Equipment for Welding Schools

Group 1—Requirements for Each Trainee While Welding

Welding goggles with suitable color filter lens and clear cover glass
Leather gloves (needed principally for welding heavier materials only)
Apron of fire-resistant material
Pick-up tongs or pliers
Container for welding rods
Metal quenching tank convenient to several stations
Facilities on or near welding table for positioning work

Group 2—For Trainee Observers and Instructors While Observing

Welding goggles with suitable color filter lenses and clear cover glass
Apron of fire-resistant material

Group 3—Small Tools and Accessories

1- or 2-lb. ball peen hammer
2-in. to 6-in. C-clamps
Cold chisels
Prick punches
Scribers
Metal rules, 12 in. long or longer
12-in. try squares
Sets of metal marking steel stencils (letters and figures, $^3/_{16}$ in.)
Small steel wedges
8-in. or 12-in. medium coarse files for rounding edges of test specimens
8-in. or 10-in. fine files for preparing specimens for etching
Emery cloth in several grades ranging from medium to very fine for preparation of specimens for etching. (grades 1 to 000 recommended)
Etching solution (10–20% ammonium persulphate recommended)
Hand-hack-saw frame and high-speed blades of 32 teeth per inch
1-in. or 2-in. micrometer (for tension tests)
3× magnifying glass for visual examination of welds

Group 4—Shop Machines and Equipment

Heavy work bench with machinist's or blacksmith's vise weighing 70 lb or more
Cutting torch (manual or machine guided) or plate shear for preparing plates and tubing for welding and for cutting test specimens
Two-ended pedestal grinder with 8-in. by 1-in. (or larger) wheels, one coarse and one fine
Safety goggles for use while grinding
Heavy power hack-saw (preferably with 10-in. width capacity)
Equipment for machining test specimens
Guided-bend test device with hydraulic jack of 5-ton or larger capacity
Fire extinguishers, chemical
Fire buckets, water
Sand bags or sand buckets for fire protection
Scrap box (about 36 in. by 24 in. by 12 in.)
Chartboard for progress chart, instructional charts and notices
First aid kit
Provisions for sterilizing welding goggles
Tension testing equipment or access thereto
Display board showing satisfactorily completed exercises

APPENDIX B

Testing—Apparatus and Applications

generally to a U-shape. The specimen should then be removed from the jig and its convex surface examined for the appearance of cracks or other open defects. Any specimen in which a crack or other open defect is present in the weld or within the zone of fusion after the bending, exceeding

Fig. 21—Cluster Joint of Sheet and Tubing (Test Joint No. 4)

Tension testing equipment
Display board showing satisfactorily completed exercises

APPENDIX B

Testing—Apparatus and Applications

Introduction

The material in this appendix is intended to provide the trainee, and the instructor, with a summary of the various testing methods referred to in the mandatory part of this Code.

Before proceeding with the description of the various testing methods, it is important to note that welded specimens should not be tested until they have been cooled in still air.

Appearance

Before any weld specimens are tested, they should be examined for appearance. The contour of the face of the weld should be uniform throughout its entire length. There should be no evidence of overlapping or undercutting. The root of the weld should show complete penetration with no "icicles" in evidence, and the top edge of the base metal should be completely fused with the weld metal. Further, the ends of the weld should be uniform with the rest of the weld and should not be built up excessively or insufficiently.

Hammer Test—Corner Joints

The hammer test, as applied to corner joints, is perhaps the simplest to perform. However, it is probably the most important test of all since it is the trainee's introduction to weld testing and the interpretation of results.

The welded specimen is held firmly by a pair of tongs or pliers in the position shown in Fig. 6*a*. It is struck sharp blows with a heavy hammer until the plates are completely flattened, as shown in Fig. 6*b*. Specimens bent as in Fig. 6*c* are of little value since they are not properly flattened. Before bending, the weld cross section should be as shown in Fig. 6*d*.

Guided-Root-Bend Test

Although the final tests prescribed in this Code are tested by means of the tension test, it has proven simpler and more expedient to substitute other techniques for the check tests. Therefore, a modified guided-root-bend test is used for butt joints since experience has shown that a specimen which will successfully withstand this test will also withstand the tension test. This special guided-root-bend test is performed as follows:

The welded joint as shown in Fig. 7 should be bent in a jig having the working contour shown in Fig. 8 and otherwise substantially in accordance with that figure. Any convenient means may be used for moving the plunger member with relation to the die member. The specimen should be placed on the die member of the jig with the weld at midspan and with the root of the weld directed toward the gap. The two members of the jig should be forced together until the curvature of the specimen conforms generally to a U-shape. The specimen should then be removed from the jig and its convex surface examined for the appearance of cracks or other open defects. Any specimen in which a crack or other open defect is present in the weld or within the zone of fusion after the bending, exceeding $^1/_8$ in. measured in any direction, should be considered as having failed.

Most of the exercises required in this course involve making welds in sheet or thin plate, which, if defective, may readily be broken apart to permit examination of the weld for the cause of failure. It is therefore recommended that this practice be followed wherever practicable, immediately after each weld is completed and has been cooled in still air, so that the trainee can see the results of his previous work before proceeding to make the next weld.

Hammer Test—Lap Joints

Fillet-welded, lap joint specimens are held in a vise and struck with a heavy hammer, as shown in Fig. 12*a* until they assume the shape of a "tee" shown in Fig. 12*b*. In some cases it may be necessary to employ a wedge to aid in separating the plates at the unwelded edge. After bending, there should be no evidence of pulling away of the top plate from the bottom one. The contour of the weld before bending should conform to Fig. 12*c*. If the weld is of much greater size, it is too large and, therefore, uneconomical.

Hammer Test—Tee Joints

Fillet-welded, tee joint specimens are held in a vise and the bend is started as shown in Fig. 14*a*. The specimen is then removed from the vise and reinserted in such a manner that pressure may be exerted to cause the vertical plate to become parallel to the base plate as shown in Fig. 14*b*. An acceptable weld will bend without any cracking or tearing away of one plate from another. All of the elongation should take place in the vertical plate and there should be no evidence of burning through.

Tension Test

The Tension Test as employed in the final tests for this Code is made by submitting the properly prepared welded specimen shown in Fig. 18*b* to a longitudinal load of sufficient magnitude to pull the piece apart (see Fig. 18*a*). Before testing, dimensions necessary for calculating the breaking stress are recorded. As the specimen is being tested, the load, in pounds, to which it is being subjected is registered either on a gage or balancing beam, depending on the type of testing machine. When fracture occurs, the value of this load is entered in the records.

The standard tension test is employed for Test No. 1, while various modifications are employed for Tests Nos. 2 and 3. The method employed for each of these tests is indicated below.

(*a*) *Test No. 1—Butt Joint in Plate*

The specimens cut from the plate are prepared as shown in Fig. 18*b*, and the width and thickness of the weld metal are recorded. From these dimensions, the cross-sectional area of the weld metal is computed. The

tensile strength, defined as the stress in pounds per square inch, is calculated by dividing the recorded load by the cross-sectional area of the weld metal computed above. The values which should be obtained are listed in Table I, Article 603.

(*b*) *Test No. 2—Butt Joint in Tubing*

For tubular specimens, the cross-sectional area of the tubing is computed, since the reinforcement is retained. These specimens are tested in tension as described above. The tensile strength is calculated by dividing the breaking load by the cross-sectional area of the tube. The required values are indicated in Article 604. Plugs are inserted in the tube before testing as shown in Fig. 19*b*.

(*c*) *Test No. 3—Double Tee Joint (Cross)*

This specimen is prepared as shown in Fig. 20*b* and dimension A is recorded. Since it is not necessary to calculate the stress in pounds per square inch, it is not necessary to determine the cross-sectional area of the specimen. Rather, the stress in pounds per linear inch of specimen width is required. Therefore, the breaking load is divided by the specimen width A to determine the stress in pounds per linear inch of weld. Required values are given in Article 605.

Etching

Etching is a chemical process used to indicate the depths of penetration and fusion and the grain structure in weld and adjacent metal. The technique described herein represents a simplification of the procedures generally employed in metallurgical laboratories for etching metals. This simple method is designed for welding school use and is not a substitute for existing metallographic techniques.

Test No. 4—Cluster Joint of Sheet and Tubing

After cutting the Specimen across Section AA as shown in Fig. 21, a cross section of the weld is obtained and by employing files with increasingly finer cuts the surface of the section is made fairly smooth. The surface should then be polished with sand or emery paper starting with No. 1 and finishing with No. 000. Filing and polishing should be such that each operation is at 90° to the previous operation and is continued until all marks of the former operation are removed. Do not touch the polished surface with hands and keep it free of grease or dirt. Great care must be taken to keep the polished surface clean since any foreign substances will prevent proper action of the etching solution. Then apply a 10–20% solution of ammonium persulphate with a small cloth or wad of cotton. A 50% hydrochloric acid solution or a 5% nital solution also may be used, but the first solution is by far the safer for school use. The etched surface should then be washed with water and drying expedited with alcohol. If the test specimen is to be preserved, the surface should be coated with transparent varnish or lacquer. Examine weld for soundness and depth of fusion and penetration. Look for gas pockets and non-metallic inclusions. Figure 21 illustrates a satisfactory weld cross section for Test No. 4 as revealed by etching.

APPENDIX C

Recommended Safety Rules

This appendix contains some of the more important safety precautions for both trainees and instructors. It is recommended that these safety precautions be completely covered in a lecture by the instructor. Further, these lectures should be accompanied by suitable demonstrations in the shop.

It should be realized that a fully competent mechanic is one who not only knows the technical aspects of his trade, but also the safety precautions necessary to insure safe operation of equipment. He must be able to recognize hazards quickly and know how to avoid or correct them. *A careless operator is a hazard not only to himself, but also to everyone near him.*

Therefore, this topic should be presented in such a manner as to impress the trainee with the importance of becoming thoroughly familiar with the Safety Rules listed below.

As a further precaution, it is recommended that the school secure for the trainee's study, safety pamphlets from the various organizations and manufacturers in this industry.

SAFETY RULES

OXYGEN

1. Always refer to oxygen by its full name "oxygen" and not by the word "air."
2. Never use oxygen near inflammable materials, especially grease, oil or any substance likely to cause or accelerate fire. Oxygen itself is not inflammable but does support combustion.
3. Do not store oxygen and acetylene cylinders together. They should be separately grouped.
4. Never permit oil or grease to come in contact with oxygen cylinders —valves—regulators—hose or fittings. Do not handle oxygen cylinders with oily hands or oily gloves.
5. Never use oxygen regulators, hose or other pieces of apparatus with any other gases.
6. Open oxygen cylinder valve fully when in use.
7. Never attempt to mix any other gases in an oxygen cylinder.
8. Be certain that cylinder valve is tightly closed before handling cylinder.
9. Never use oxygen from cylinders without a suitable regulator attached to the cylinder valve.
10. Never tamper with nor attempt to repair oxygen cylinder valves.

ACETYLENE

1. Call acetylene by its full name "acetylene" and not by the word "gas." Acetylene is far different from city or furnace gas.

2. Acetylene cylinders should be used and stored in an upright posi-

11. Don't use white lead, oil or grease, or other pipe fitting compounds to make joints.

2. Acetylene cylinders should be used and stored in an upright position.
3. Keep sparks, flames and heat away from acetylene cylinders.
4. Never use acetylene from cylinders without reducing the pressure through a suitable regulator attached to the cylinder valve.
5. Turn the acetylene valve so that the valve outlet will point away from the oxygen cylinder.
6. When opening an acetylene cylinder, turn key about one full turn.
7. Acetylene cylinder key for opening cylinder valve must be kept on valve stem while cylinder is in use so that the acetylene cylinder may be quickly turned off in an emergency.
8. Never use acetylene regulators, hose or other pieces of apparatus with any other gases.
9. Never attempt to transfer acetylene from one cylinder to another nor to refill an acetylene cylinder, nor to mix any other gas or gases in an acetylene cylinder.
10. When returning empty cylinders make certain that valves are closed tightly to prevent escape of residual acetylene.
11. Should a leak occur in an acetylene cylinder take cylinder out in the open air, keeping well away from fires or open lights. Notify the manufacturer at once.
12. Never use acetylene at pressures in excess of 15 psi.; the use of higher pressures is prohibited by all insurance authorities and by law in many localities.

Caution

When working from oxygen and acetylene pipe lines connected to manifolds and generators, the instructor shall give the trainee specific directions on setting up, taking down and safety precautions applicable to this equipment.

GENERAL PRECAUTIONS

1. Don't permit anyone to strike an arc on a compressed gas cylinder.
2. Don't weld in the vicinity of inflammable or combustible materials.
3. Don't weld on containers which have held combustible or inflammable materials without first exercising the proper precautions recommended by the AMERICAN WELDING SOCIETY. (Recommended Procedure to Be Followed in Welding or Cutting Containers Which Have Held Combustibles.)
4. Don't weld in confined spaces without adequate ventilation.
5. Don't pick up hot objects.
6. Don't do any chipping or grinding without suitable safety goggles.
7. Don't move individual cylinders without the cap over the cylinder valve.
8. Don't drop or abuse cylinders in any other way.
9. Make certain that cylinders are well fastened in their stations so that they will not fall.
10. Don't use a hammer or wrench to open cylinder valves. If the valves cannot be opened by hand, notify the instructor.
11. Don't use white lead, oil or grease, or other pipe fitting compounds to make joints.
12. Never force connections which do not fit.
13. Never tamper with fusible plugs.
14. Always protect hose from being trampled on or run over. Avoid tangles and kinks. Don't leave the hose so that it can be tripped over because a connection may be pulled off, or worse still, the cylinders and equipment may be pulled over.
15. Protect the hose from flying sparks, hot slag, hot objects and open flame.
16. Don't allow hose to come in contact with oil or grease; these deteriorate the rubber and constitute a hazard with oxygen.
17. Be sure that the connections between the regulators, adapters and cylinder valves are tight. Escaping acetylene can generally be detected by the odor. Test with soapy water, never with an open flame.
18. Don't use matches for lighting torches; hand burns may result. Use friction lighters, stationary pilot flames or some other suitable source of ignition; do not light torches from hot work in a pocket or small confined space. Don't attempt to relight a torch that has "blown out" without first closing both torch valves and relighting in the proper manner.
19. Don't hang a torch with its hose on regulators or cylinder valves.
20. Don't cut material in such a position as will permit sparks, hot metal or the severed section to fall on the cylinder, hose, legs or feet.
21. When welding or cutting is to be stopped temporarily, release the pressure adjusting screws of the regulators by turning them to the left.
22. When the welding or cutting is to be stopped for a long time (during lunch hour or overnight), close the cylinder valves and then release all gas pressures from the regulators by opening the torch valves momentarily. Close the torch valves and release the pressure adjusting screws. If the equipment is to be taken down, make certain that all gas pressures are released from the regulators and that the pressure adjusting screws are turned to the left until free.

APPENDIX D

Welding Rods

The material in this appendix is intended to provide the trainee and the instructor with a summary of the properties and applications of the several types of gas welding rods covered by the A.W.S.-A.S.T.M. Tentative Specifications for Iron and Steel Gas-Welding Rods—Serial Designation A251. In addition, comments are provided indicating the application of these rods to aircraft welding.

The general definition of a welding rod, as given in the American Welding Society's "Definitions of Welding Terms and Master Chart of Welding Processes," is as follows: "Filler metal in wire or rod form, used in the gas welding process and those arc welding processes wherein the electrode does not furnish the deposited metal." Obviously, the latter part of this definition pertaining to arc welding does not apply to this Code.

The classifications and requirements of oxyacetylene welding rods as established by the specifications are given in Table I.

Table I—Tensile Requirements of Deposited Metal (Using 3/16-In. or 1/4-In. Welding Rods)

Welding Rod Classification Number	Plate Thickness, In.	Treatment of Welded Specimen*	Tension Test Requirements	
			Tensile Strength, Min. Psi.	Elongation in 2 In., Min. Per Cent
GA65	3/4	SR	65,000	20
		NSR	72,000	17
GA60	3/4	SR	60,000	25
		NSR	62,000	20
GA50	3/4	SR	50,000	28
		NSR	52,000	23
GB65	3/4	SR	65,000	18
		NSR	72,000	15
GB60	3/4	SR	60,000	20
		NSR	62,000	15
GB45	3/8	NSR	45,000†	..

* The abbreviations SR and NSR signify stress-relieved and non-stress-relieved, respectively. Stress-relieving when prescribed in these specifications is for the purpose of developing the fundamental properties of the weld metal unaltered by locked-up stress. Values obtained from stress-relieved welded specimens are about 5 per cent lower in tensile strength and 10 to 20 per cent higher in elongation than those of non-stress-relieved specimens. Stress-relieving shall be within the range of 1150° plus or minus 25° F. for one hour per inch of thickness. Specimens shall be heated in a suitable furnace at the rate of 300° to 350° F. per hour until a temperature of 1150° plus or minus 25° F. has been attained. After this temperature has been reached, it shall be maintained for one hour for each inch or fraction thereof of the maximum thickness of the section. The specimens shall be cooled at the same rate specified for heating and may be removed from the furnace when the temperature of the plates has reached 300° F.

† This value shall be obtained with the full-section tension test specimen shown in Fig. 2 of the specifications. All other values in this column shall be obtained with the all-weld-metal tension test specimen shown in Fig. 1 of the specifications.

In addition, the military and naval aircraft authorities have issued filler metal specifications written in terms of their specific needs. For the welding of aircraft grades of plain carbon and alloy steels, two types of rods are in general use. These two types are covered by classification numbers GA60 and GA50. The former is usually a low-alloy steel analysis while the latter is a low carbon (0.06% max.) steel.

Welding rods conforming to GA50 are extensively used for aircraft assemblies not subjected to heat treatment after welding. These rods, while inherently of low tensile strength, are used successfully in the welding of such alloys as SAE 4130, producing welds which give excellent service. This is achieved by reason of the fact that in welding thin alloy materials, a portion of the alloying ingredients of the base metal is mixed with the filler metal yielding a weld metal of a strength intermediate between that of the base metal and the normally deposited filler metal. This effect, sometimes called "migration," is more pronounced on thicknesses 1/8 in. and less and is practically ineffective on thicknesses above 1/4 in.

A manifestation of this effect is found in welds made in the tubular butt joints, Test No. 2 (Article 604). This test is made by subjecting the welded tubular joints to tension tests, retaining the weld reinforcement. Properly made welds with GA50 rods almost invariably fail in the tubes at tensile values of 95,000–105,000 psi., calculated on the area of the tubing.

It will be noted that welding rods conforming to classification GA60 deposit welds of intrinsically higher tensile strength; further, they possess better weldability than the GA50 rods. In addition, welds made with these rods may be heat treated to give higher tensile strengths. For these reasons many welding engineers prefer their use for aircraft assemblies.

For the instruction covered by this Code, it is recommended that welding rods conforming to classification GA50 be used in welding the exercises and the check tests, and rods conforming to classification GA60 be used only on the final tests.

It should be appreciated that rods conforming to the other classifications of Table I, as well as special analysis rods, are used for special classes of work. However, it will be found that in welding with higher strength rods, cracking in and adjacent to the weld (particularly on alloy steel) will present problems. This may be overcome by suitable preheating, but this phase of aircraft welding is not included in the present Code.

Group B *(Continued)*

B-4	1/8	3/32	Practicing forehand bead welds with filler metal. These beads should be uniform in height and

the all-weld-metal tension test specimen shown in Fig. 1 of the specifications.

APPENDIX E

Suggested Exercises

Notes:

1. In the following list of suggested welding exercises, no specific recommendations are made with respect to the number of times each exercise should be repeated. The trainee should be required to perform each exercise to the satisfaction of the instructor before being permitted to advance to the next exercise.

2. It is recommended that the trainee test each of his welds as soon as it has been cooled in still air. Further, the instructor should inspect the tested weld and point out to the trainee any defects that may be in evidence and the reason for such defect or failure of the joint. The required techniques of testing are described in Appendix B.

3. The exercises in Groups A through E inclusive, are for Course I. The exercises in Groups F through H, inclusive, are for Course II.

4. It is recommended that the size of specimen, as indicated in the various illustrations, be maintained wherever possible.

5. It is recommended that the pieces be set up and tack welded before welding.

COURSE I

Group A—Setup

Before the trainee is permitted to use any oxyacetylene equipment, the instructor should give a lecture and demonstration completely covering the operations involved in setting up, adjusting and taking down the oxyacetylene equipment.

Group B—Bead Welds and Corner Joints

Exercise Number	Plate Thickness, In. A and B	Welding Rod Diameter, In.	Instructions
B-1	1/16	None	Practicing forehand bead welds without filler metal.
B-2	1/8	None	Practicing forehand bead welds without filler metal.
B-3	1/16	1/16	Practicing forehand bead welds with filler metal. These beads should be uniform in height and width with no overlapping or undercutting and approx. 25% reinforcement.
B-4	1/8	3/32	Practicing forehand bead welds with filler metal. These beads should be uniform in height and width with no overlapping or undercutting and approx. 25% reinforcement.
B-5	1/16	1/16	Making corner joints in the flat position as shown in Fig. 1*b* using the forehand technique. (Check Test No. 1)
B-6	1/8	1/16	Making corner joints in the flat position as shown in Fig. 1*b* using the forehand technique. (Check Test No. 2)

Test: Specimens made in Exercises B-5 and B-6 should pass the hammer test for corner joints as described in Appendix B.

Group C—Butt Joints in Steel Sheet

Exercise Number	Plate Thickness, In. A	Welding Rod Diameter, In.	Instructions
			Note: All specimens in this group should be of the dimensions indicated in Fig. 7 with the thickness A indicated in the column headed "Plate Thickness.
C-1	1/16	1/16	Making square groove welded butt joints in the flat position as shown in Fig. 1*a* with 1/32-in. spacing at the root of the weld. Use forehand technique.
C-2	1/8	1/16	Making square groove welded butt joints in the flat position as shown in Fig. 1*a* with 1/16-in. spacing at the root of the weld. Use forehand technique. (Check Test No. 3)
C-3	1/16	1/16	Making square groove welded butt joints in the flat position as shown in Fig. 1*a* with 1/16-in. spacing at the root of the weld. Use forehand technique.
C-4	1/8	1/16	Making square groove welded butt joints in the flat position as shown in Fig. 1*a* with 1/8-in. spacing at the root of the weld. Use forehand technique.
C-5	1/16	1/16	Making square groove welded butt joints in the flat position as shown in Fig. 1*a* with the sheets touching at the start and spaced 1/16 in. at the other end. Use forehand technique.
C-6	1/8	1/16	Making square groove welded butt joints in the flat position as shown in Fig. 1*a* with the sheets touching at the start and spaced 1/8 in. at the other end. Use forehand technique.
			Note: For all future exercises, the root spacing should be one-half the thickness of the base metal unless otherwise specified.
C-7	1/8	1/16	Making square groove welded butt joints in the flat position as shown in Fig. 1*a* using the backhand technique. (Check Test No. 4)
C-8	1/16	1/16	Making square groove welded butt joints in the vertical position as shown in Fig. 3*a* using the forehand technique.

Group C *(Continued)*

C-9	1/8	1/16	Making square groove welded butt joints in the vertical position as shown in Fig. 3*a*, using the forehand technique. (Check Test No. 5)
C-10	1/8	1/16	Making square groove welded butt joints in the vertical position as shown in Fig. 3*a*, using the backhand technique. (Check Test No. 6)
C-11	1/16	1/16	Making square groove welded butt joints in the overhead position as shown in Fig. 4*a* using the forehand technique.
C-12	1/8	1/16	Making square groove welded butt joints in the overhead position as shown in Fig. 4*a*, using the forehand technique. (Check Test No. 7)
C-13	1/8	1/16	Making square groove welded butt joints in the overhead position as shown in Fig. 4*a*, using the backhand technique. (Check Test No. 8)

Test: All specimens made in this group of exercises should meet the appearance and bend test requirements specified in Article 407.

Group D—Butt Joints in Steel Plate

Exercise Number	Plate Thickness, In. A	Welding Rod Diameter, In.	Instructions
D-1	3/16	3/32	Making single vee groove welded butt joints in the flat position as shown in Fig. 1*a*, using forehand technique.
D-2	3/16	3/32	Making single vee groove welded butt joints in the flat position as shown in Fig. 1*a*, using the backhand technique.
D-3	1/4	1/8	Making single vee groove welded butt joints in the flat position as shown in Fig. 1*a*, using the forehand technique. (Check Test No. 9)
D-4	1/4	1/8	Making single vee groove welded butt joints in the flat position as shown in Fig. 1*a*, using the backhand technique. (Check Test No. 10)
D-5	3/16	3/32	Making single vee groove welded butt joints in the vertical position as shown in Fig. 3*a*, using the forehand technique.
D-6	3/16	3/32	Making single vee groove welded butt joints in the vertical position as shown in Fig. 3*a*, using the backhand technique.
D-7	1/4	1/8	Making single vee groove welded butt joints in the vertical position as shown in Fig. 3*a*, using the forehand technique. (Check Test No. 11)
D-8	1/4	1/8	Making single vee groove welded butt joints in the vertical position as shown in Fig. 3*a*, using the backhand technique. (Check Test No. 12)

Test: All specimens made in this group of exercises should meet the appearance and bend test requirements specified in Article 409.

Group E—Tubing

Exercise Number	Tube Sizes, In. O.D.	Tube Sizes, In. Wall Thick.	Welding Rod Diameter, In.	Instructions *Note:* For these practice exercises, 3-in. lengths of tube should be used as shown in Fig. 9
E-1	1	0.070 max.	1/16	Making butt joints in tubing in the horizontal rolled position at bench level as shown in Fig. 10*a*.
E-2	1	0.070 max.	1/16	Making butt joints in tubing in the vertical position at bench level (may be rotated). See Fig. 10*b*.
E-3	1	0.070 max.	1/16	Making butt joints in tubing in the horizontal fixed position at eye level. See Fig. 10*c*. (Check Test No. 13)
E-4	1	0.070 max.	1/16	Making butt joints in tubing in the vertical fixed position at eye level. See Fig. 10*d*. (Check Test No. 14)

Test: All specimens made in this group of exercises should meet the appearance and etch test requirements prescribed in Article 411.

The exercises covered thus far encompass the work of Course I.

COURSE II

Group F—Fillet Welds on Lap Joints

Exercise Number	Plate Thickness, In.* A	Plate Thickness, In.* B	Welding Rod Diameter, In.	Instructions
F-1	1/16	1/16	1/16	Making fillet welds on lap joints as shown in Fig. 11 and welded in the horizontal position as shown in Fig. 2*d*, using the forehand technique.
F-2	1/8	1/8	1/16	Making fillet welds on lap joints as shown in Fig. 11 and welded in the horizontal position as shown in Fig. 2*d*, using the forehand technique.
F-3	1/8	1/8	1/16	Making fillet welds on lap joints as shown in Fig. 11 and welded in the horizontal position as shown in Fig. 2*d*, using the backhand technique.
F-4	1/16	1/16	1/16	Making fillet welds on lap joints as shown in Fig. 11 and welded in the vertical position as shown in Fig. 3*d*, using the forehand technique.
F-5	1/8	1/8	1/16	Making fillet welds on lap joints as shown in Fig. 11 and welded in the vertical position as shown in Fig. 3*d* using the forehand technique.
F-6	1/8	1/8	1/16	Making fillet welds on lap joints as shown in Fig. 11 and welded in the vertical position as shown Fig. 3*d*, using the backhand technique.

Group F *(Continued)*

G-8	1/16	1/4	1/16	Making fillet welds on tee joints as shown in Fig.

Test: All specimens made in this group of exercises should meet the appearance bend test requirements specified in Article 409.

Group F *(Continued)*

F-7	1/16	1/16	1/16	Making fillet welds on lap joints as shown in Fig. 11 and welded in the overhead position as shown in Fig. 4*d*, using the forehand technique.
F-8	1/8	1/8	1/16	Making fillet welds on lap joints as shown in Fig. 11 and welded in the overhead position as shown in Fig. 4*d*, using the forehand technique.
F-9	1/8	1/16	1/16	Making fillet welds on lap joints as shown in Fig. 11 and welded in the horizontal position as shown in Fig. 2*d*, using the forehand technique. (Check Test No. 15)
F-10	1/16	1/8	1/16	Making fillet welds on lap joints as shown in Fig. 11 and welded in the vertical position as shown in Fig. 3*d*, using the backhand technique.
F-11	1/8	1/16	1/16	Making fillet welds on lap joints as shown in Fig. 11 and welded in the vertical position as shown in Fig. 3*d*, using the forehand technique. (Check Test No. 16)

Test: All specimens made in this group of exercises should meet the appearance and hammer test requirements prescribed in Article 413.
* For interpretation of thicknesses A and B, see Fig. 11.

Group G—Fillet Welds on Tee Joints

Exercise Number	Plate Thickness, In.* A	Plate Thickness, In.* B	Welding Rod Diameter, In.	Instructions
G-1	1/8	1/8	3/32	Making fillet welds on tee joints as shown in Fig. 13 in the horizontal position as shown in Fig. 2*c*, using the forehand technique.
G-2	1/16	1/8	1/16	Making fillet welds on tee joints as shown in Fig. 13 in the horizontal position as shown in Fig. 2*c*, using the forehand technique.
G-3	1/8	3/16	3/32	Making fillet welds on tee joints as shown in Fig. 13 in the horizontal position as shown in Fig. 2*c*, using the forehand technique.
G-4	1/8	1/4	3/32	Making fillet welds on tee joints as shown in Fig. 13 in the horizontal position as shown in Fig. 2*c*, using the forehand technique.
G-5	1/8	1/4	3/32	Making fillet welds on tee joints as shown in Fig. 13 in the horizontal position as shown in Fig. 2*c*, using the backhand technique.
G-6	1/8	1/8	3/32	Making fillet welds on tee joints as shown in Fig. 13 in the vertical position (Fig. 3*c*), using the forehand technique.
G-7	1/8	1/8	3/32	Making fillet welds on tee joints as shown in Fig. 13 in the vertical position (Fig. 3*c*), using the backhand technique.
G-8	1/16	1/4	1/16	Making fillet welds on tee joints as shown in Fig. 13 in the horizontal position (Fig. 2*c*), using the forehand technique. (Check Test No. 17)
G-9	1/16	1/4	1/16	Making fillet welds on tee joints as shown in Fig. 13 in the horizontal position (Fig. 2*c*), using the backhand technique. (Check Test No. 18)

Test: All specimens made in this group of exercises should meet the appearance and hammer test requirements prescribed in Article 415.
* For interpretation of thicknesses A and B, see Fig. 13.

Group H—Tubes to Sheets or Plates

Exercise Number	Tube Diameter, O.D., In.	Plate Thickness, In. A	Welding Rod Diameter, In.	Instructions
H-1	1	1/16	1/16	Joining slotted tube to sheet with fillet welds in the flat or horizontal position as shown in Fig. 15.
H-2	1	1/8	1/16	Joining slotted tube to sheet with fillet welds in the flat or horizontal position as shown in Fig. 15.
H-3	1	3/16	3/32	Joining slotted tube to plate with fillet welds in the flat or horizontal position as shown in Fig. 15.
H-4	1	1/4	1/8	Joining sheet to tube with fillet welds in the flat or horizontal position as shown in Fig. 15. (Check Test No. 19)
H-5	1	1/16	1/16	Joining sheet to tube with fillet welds in the vertical position as shown in Fig. 16.
H-6	1	1/8	1/16	Joining sheet to tube with fillet welds in the vertical position as shown in Fig. 16.
H-7	1	3/16	3/32	Joining plate to tube with fillet welds in the vertical position as shown in Fig. 16.
H-8	1	1/4	1/8	Joining sheet to tube with fillet welds in the vertical position as shown in Fig. 16. (Check Test No. 20)

Test: All specimens made in this group of exercises should meet the appearance and etch test requirements prescribed in Article 417.

Note: Appendices F and H are to be inserted in the final printing of this Code.

APPENDIX G

Recommended Form for Record Card

(Front Side)

(Name of School)

(City)

(State)

This Record Card certifies that

(Trainee's Name)

whose signature and identification are shown on the reverse, has completed the work and passed the final tests prescribed by the American Welding Society Code of Minimum Requirements for Instruction of Welding Operators, Part B-1, Oxyacetylene Welding of Steel-Aircraft for Course*__ preparing a trainee for the work of a Class*__ operator, and has fulfilled all the requirements prescribed therein. The duration of the course and details of the tests which the trainee has successfully passed are indicated on the reverse side of this Record Card.

By (Signature of school officer)

SCHOOL SEAL

Title (title of officer)

Date (date of issuance)

Note: This is a suggested form of record card only, and is not issued by the American Welding Society. The size of the card will be determined by the individual school adopting the form.

* The school shall insert I and "B" or II and "A" to indicate which course the trainee has taken and successfully completed.

(Reverse Side)

Title of Course:_____

Duration of Course: Total Hours:_____

Hours of Actual Welding Practice:_____

Hours of Observation of Welding, Preparing Plates for Welding, Testing Specimens, etc._____

Hours of Instruction in Related Information:_____

Photograph of Trainee

(In some cases it may be desirable to substitute for the photograph a description of the trainee, including date of birth, height, weight, color of eyes, color of hair, etc.

Social Security No.

Trainee's Signature

FINAL TESTS*

Test Number	†	Specimen Number	Width in Inches	Thick. in Inches	Area in Sq. In.	Beam Load	Psi.‡	Ppi.‡	Break‡	Date of Test	Remarks
1		1						...			
		2						...			
		3						...			
2	Punch here tests not taken	Bench Level Horizontal						... ...			
		Bench Level Vertical						... ...			
		Eye Level Horizontal						... ...			
		Eye Level Vertical						... ...			
3		1					...				
		2					...				
4		1	...	...	...	...	...	...	...		

* Final tests for Course I are Test No. 1 and Test No. 2. Final tests for Course II are Test No. 3 and Test No. 4.

† A punch mark in this column is an indication that the trainee did not take or pass the test so defaced.

‡ Psi. = Tensile strength in pounds per square inch.
Ppi. = Tensile strength in pounds per linear inch of weld.
Break = I W—in weld.
O W—outside weld.

Note: With regard to Record Cards for Course II, results for Test No. 1 and Test No. 2 may be inserted upon presentation of satisfactory evidence of their completion or approval may be indicated in the space reserved for Test No. 1 and Test No. 2 and the evidence upon which such approval is based should be permanently attached to the Record Card.

(*Continued from page 503*)

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THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

BY-LAW AMENDMENTS

At the Board of Directors' Meeting held on June 10, 1943, the following By-Law Amendments were approved. In accordance with the established policy of the Society, these Amendments are published in THE WELDING JOURNAL 30 days in advance of their submittal to the voting membership. The Amendments here offered are the result of careful study on the part of the various committees concerned with the effects of such changes. The Sections of the Society have been given opportunity to review them and the Section Advisory Committee reported to the Board of Directors that these Amendments received approval by a majority of the Sections. (Editorial Note: Changes and explanations are in italics.)

Article I, Section 2—"Membership"

"Associate Members.—An Associate Member shall be an individual interested in the science, art *and practice* of welding *and allied processes*, with the right to vote but not to hold office except in Sections as may be provided for by the By-Laws of the Section."

The separate grade for "Operating" Member shall cease on September 1, 1943, except that present Operating Members may continue in this status until the expiration of a period of two years (consecutive or otherwise) in which they hold membership in this grade. At the end of the two-year period, the Operating Member shall automatically be moved to the 'Associate' grade."

"Student Members.—A Student Member shall be an individual who is actually in attendance at a recognized college or university, taking a course leading to a degree, without the right to vote or to hold office except in Sections or *Student Chapters* as may be provided for by the By-Laws of the Section or *Student Chapter*. At the termination of the fiscal year or status as a student, affiliation as 'Student Member' shall cease."

Article II, Section 1—"Dues"

Delete—"Operating Members (resident)—$5.00. Operating Members (foreign)—$10.00."

Article III, Section 3 (New)—"Section Boundaries"

"The bounds of each Section of the AMERICAN WELDING SOCIETY shall be established by the Board of Directors."

Reletter present Sections 3 and 4 to Sections 4 and 5.

Article IV (New)—"Student Chapters"

Section 1. A Student Chapter in affiliation with the AMERICAN WELDING SOCIETY, composed of students of schools of engineering of recognized reputation, may be organized upon favorable vote by the Board of Directors. Authority for the organization of a Student Chapter at any institution shall automatically lapse if not used within one year from the date granted. The name of such an affiliated society shall be "The ——— Student Chapter of the AMERICAN WELDING SOCIETY."

Section 2. The qualifications required of a proposed Student Chapter shall include:

(*a*) An organization of students in an engineering school of approved standing.

(*b*) The endorsement of the application by the head of one of the Engineering Departments of the school.

(*c*) A minimum membership of 15 student members of the AMERICAN WELDING SOCIETY.

(*d*) A Faculty Adviser to the Student Chapter whose duties it shall be to consult with and advise the Student Chapter on matters relating to the general conduct of the chapter. The Faculty Adviser shall be a member, Associate member, or Honorary member of the Society and shall be a member of the faculty of the engineering school at which the Student Chapter is organized.

Section 3. The By-Laws of a Student Chapter shall not conflict with any provisions of the Constitution or By-Laws of the AMERICAN WELDING SOCIETY.

Section 4. Each active Student Chapter shall receive from the Society at the beginning of each academic year $25 to be used for expenses in promoting the activities of the chapter.

Section 5. Each Student Chapter shall submit to the Board of Directors an annual report not later than the end of each academic year, which shall include:

(*a*) A summary statement of the meetings held during the academic year; giving the date of each, the attendance, the principal speaker and his subject, and other pertinent information.

(*b*) Names of the officers and the members by classes, at the date of the report.

Section 6. Any address or paper presented before a Student Chapter may be offered for publication to the AMERICAN WELDING SOCIETY under the general provisions established for this procedure.

Section 7. Applications for the establishment of Student Chapters in the AMERICAN WELDING SOCIETY shall be made to the Board of Directors.

Section 8. A Student Chapter may be disbanded upon the approval of the Board of Directors, if it becomes inactive or if its continuance is considered not for the best interest of the SOCIETY. No Student Chapter shall be considered active unless it holds at least three meetings during the academic year.

Renumber present Articles IV to XIV, inclusive, as V to XV, inclusive.

Present Article IV "Officers. . ."

Section 1. The officers of the Society shall be a President, a First Vice-President, a Second Vice-President, *seven District Vice-Presidents*, a Treasurer, three Junior Past-Presidents, and twelve Directors-at-Large. There shall also be a Secretary appointed by the Board of Directors.

Section 5. The Board of Directors shall consist of the President, the First and Second Vice-Presidents, the *seven District Vice-Presidents*, the three Junior Past-Presidents, the Treasurer, and the twelve Directors-at-Large, and such Honorary Directors, not exceeding three in number, as may be elected from time to time, by unanimous vote of the Board of Directors, etc.

Present Article V, Section 1 "Geographical Districts"

There shall be *seven* districts known as *No. 1* the New York and New England; *No. 2*—the Middle Eastern; *No. 3*—the Southern; *No. 4*—the Central; *No. 5*—the Mid-Western; *No. 6*—the Mid-Southern; and *No. 7*—the Western Districts, the boundaries of which shall be determined by the Board of Directors.

Article VIII, Section 1—"Committees"

(*l*) An Educational Committee whose duties shall be to *stipulate and promote educational activities pursuant with the aims and purposes of the Society.*

(*m*) A Committee on Awards consisting of five individuals each serving for a period of five years. The appointment shall be arranged in such a way that one member shall retire on the adjournment of each Annual Meeting. The member senior in respect to service shall be Chairman. It shall be the duty of this Committee to make the awards *and nominate those to present honorary lectures at the Annual Meeting* and to arrange for the presentation of such medals, *certificates* or other awards as may be authorized by the Board of Directors.

A Flag with 46,200 Stars

THE service flag of the Bell System had 46,200 stars on May 1. It has a lot more now. Telephone men and women are serving with the armed forces everywhere.

Those who are right in the middle of the fighting realize especially the importance of the telephone job back home.

"Tell the gang," their letters say, "to keep on plugging.

"We wouldn't have the stuff for fighting if the rest of the Bell System wasn't sticking to the job and pushing through the calls that get things done.

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BELL TELEPHONE SYSTEM

★ *Your continued help in making only vital calls to war-busy centers is more and more essential every day.*

DRAFT OF BY-LAWS SUGGESTED FOR A STUDENT CHAPTER OF THE AMERICAN WELDING SOCIETY

Approved by the Board of Directors at its Meeting on June 10, 1943

ARTICLE I

Name

Section 1. The name of this organization shall be the ——— Student Chapter of the AMERICAN WELDING SOCIETY, hereinafter called the Chapter.

ARTICLE II

Objects

Section 1. The objects of the Chapter shall conform to those of the AMERICAN WELDING SOCIETY.

Section 2. In furtherance of these objects the Chapter shall hold meetings for the presentation of appropriate papers and the interchange of ideas. Where practicable the Chapter shall promote inspection trips and educational lecture courses.

ARTICLE III

Membership

Section 1. All members of the AMERICAN WELDING SOCIETY attending ——— College or University as students shall be considered members of this Chapter.

Section 2. All members of the Chapter who are in good standing shall have the right to vote and hold office.

ARTICLE IV

Adviser

Section 1. There shall be a Faculty Adviser to the Chapter whose duties shall be to consult with and advise the Chapter on matters relating to the general conduct of the Chapter. The Faculty Adviser shall be a member, associate member or honorary member of the AMERICAN WELDING SOCIETY and shall be a member of the faculty of the ——— College or University.

Section 2. The Faculty Adviser shall be *ex-officio* a member of the Executive Committee.

ARTICLE V

Meetings

Section 1. Regular meetings of the Chapter shall be held at such time and place as may be selected by the Executive Committee.

Section 2. At least four meetings shall be held during each regular academic year.

Section 3. The annual meeting of the Chapter shall be held in the month of ——— of each year for the election of Chapter Officers and for the transaction of such other business as may require action by the Chapter membership.

ARTICLE VI

Management

Section 1. The officers of the Chapter shall consist of a Chairman, a Vice-Chairman, a Secretary and a Treasurer, all of whom shall be elected for a term of one academic year by the Chapter at the organization meeting and at each annual meeting thereafter. The offices of Secretary and Treasurer may be combined if desired.

Section 2. The Management of the Chapter shall be vested in an Executive Committee consisting of the Officers of the Chapter and the Faculty Adviser.

Section 3. The Executive Committee shall have power to fill vacancies in its membership, such appointees to hold office for the unexpired term of the vacating members.

Section 4. The Executive Committee may hold meetings, subject to the call of the Chairman, as often as the interests of the Chapter demands.

Section 5. At all meetings of the Executive Committee —— members shall constitute a quorum.

Section 6. The Chairman shall appoint an Auditing Committee of at least three members to audit the books of the Chapter and who shall submit the results of their audit to the Executive Committee prior to the annual meeting of the Chapter.

Section 7. The Treasurer shall prepare an annual report showing the receipts and disbursements for the year. Such report shall be presented at the annual meeting.

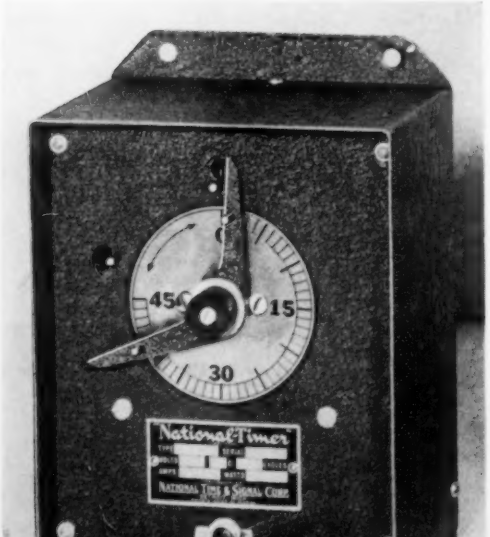
ARTICLE VII

Elections

Section 1. Each year (at least 30 days prior to the annual meeting) the Chairman of the Chapter, with the approval of the Executive Committee, shall appoint a Nominating Committee consisting of —— members.

Section 2. The Nominating Committee shall report the names of their nominees for office at the annual meeting.

NATIONAL CLUTCHLESS INTERVAL TIMERS



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1. Non-repeat Control. Operator starts Timer, Load goes 'On'. At end of pre-set Interval, Load 'Off'. Timer stops.
2. Same as #1, except a warning signal, (either light or bell) is initiated by Timer at end of operation.
3. Delayed Action. Operator starts Timer. After pre-set Interval, Load goes 'On' and Timer Stops.
4. Double Circuit Non-repeat. Operator starts Timer. #1 Load goes 'On' and times out. #2 Load then goes 'On' for same Interval, then 'Off', following which, Timer stops.
5. Repeat 'On' and 'Off'. Timing Interval for each period the same.
6. Repeat Operation to control 2 Load Circuit, alternately. #6 is a 3 Wire Load Circuit with common feed. #6a has no common feed.
7. Simple Repeat Control, without Load Circuit, to ring a bell, or light a light momentarily, at the end of each pre-set time Interval.
8. Sequence Type, with variable pre-set timed Intervals, to perform several operations in timed sequence, and stop.

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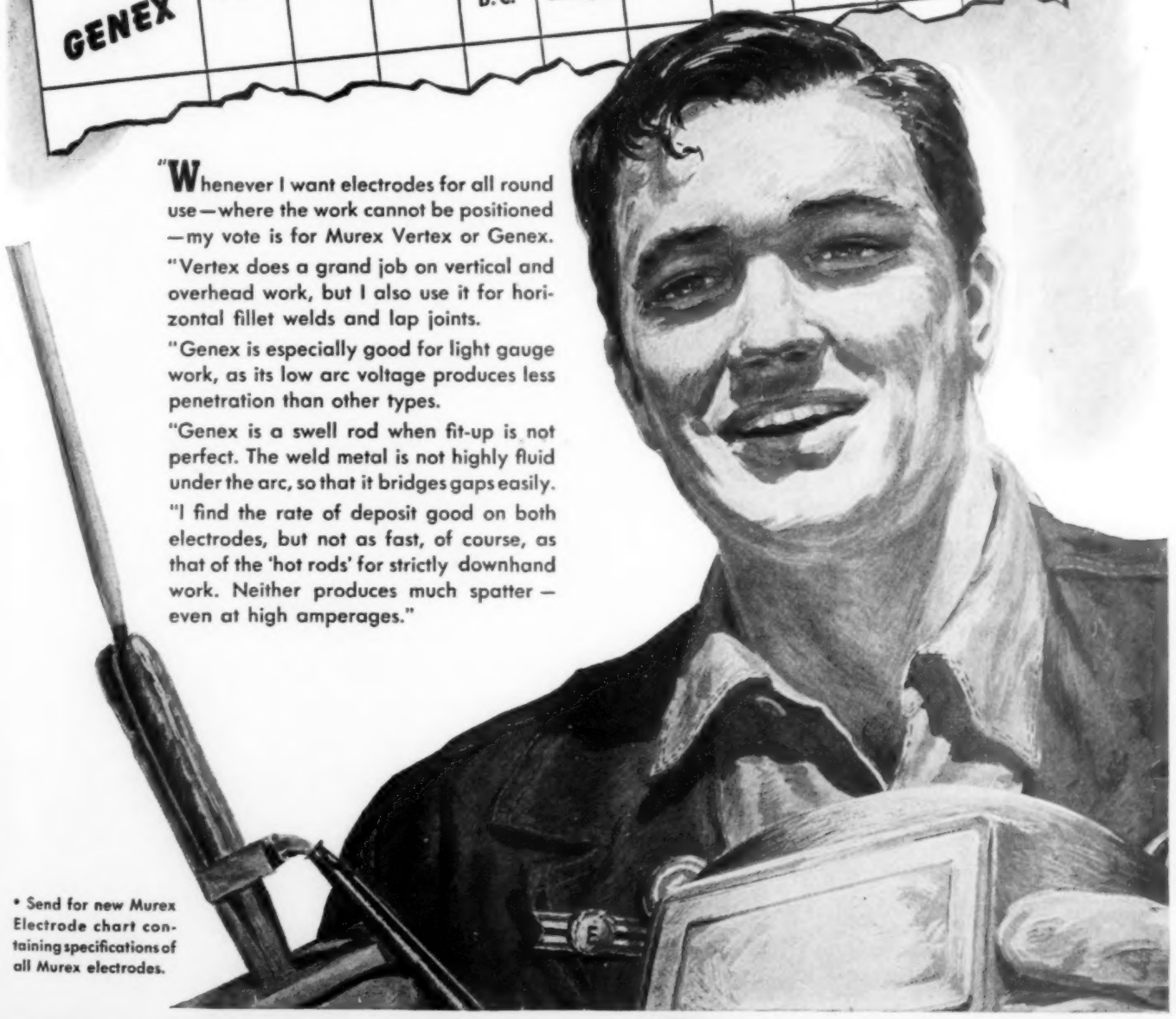
VERTEX	E-6010	Gray	None	D.C.	Reverse	Reverse	62,000 to 70,000	60,000 to 66,000	22 to 30	27 to 34
GENEX	E-6012	Tan	None	A.C. or D.C.	Straight	Straight	68,000 to 80,000	65,000 to 69,000	17 to 25	22 to 26



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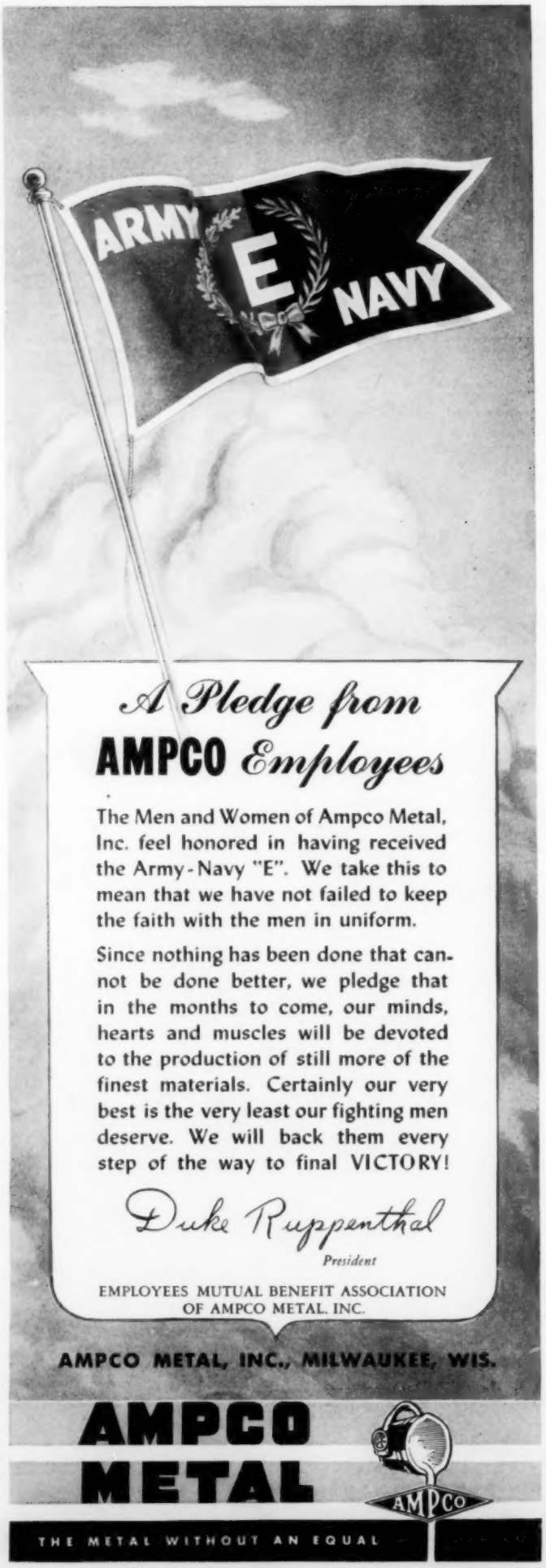
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INDEX TO ADVERTISERS

Air Reduction Sales Co. . . . . Outside back cover
American Brass Company 561
American Chain & Cable Company, Inc. 555
American Optical Co. 577
American Telephone & Telegraph Co. 547
Ampco Metal, Inc. 550
Anti-Borax Compound Company 580
Arcos Corp. . . . . Inside front cover
Bastian-Blessing Co. 560
Champion Rivet Co. 563
Electroloy Co., Inc. 576
Emerson Electric Mfg. Co. 565
Eutectic Welding Alloys Co. 572
Frederick Gumm Chemical Co. 497
General Electric Co. 559
General Electric Co. . . . . Insert 586 & 587
Glenn-Roberts Company 562
Harnischfeger Corporation . . . . . Insert 583 & 584
Haynes Stellite Company 571
Hobart Bros. Co. 495
International Nickel Co., Inc. 585
The Lincoln Electric Co. . . . . Inside back cover
The Linde Air Products Company 498
P. R. Mallory & Co., Inc. 564
Metal & Thermit Corporation 549
Miller Electric Mfg. Co. 570
National Carbide Corporation 568
National Time & Signal Corp. 548
Oakite Products, Inc. 560
Page Steel & Wire Division 555
Ransome Machinery Co. 554
The Reid-Avery Company 573
Resistance Welder Mfrs. Association 553
Sciaky Bros. 575
Shawinigan Products Corp. 558
The Sight Feed Generator Company 552
A. O. Smith Corporation 579
Una Welding Inc. 569
Union Carbide and Carbon Corp. . . . . 498 & 571
Victor Equipment Co. 551
Westinghouse Elec. & Mfg. Co. . . . . 556 & 557
Wilson Welder & Metals Co., Inc. 567

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A serious shortage of oxygen, acetylene, and calcium carbide is imminent. Acetylene (which is generated from calcium carbide) and oxygen are used for welding and cutting in the manufacture of steel, ships, airplanes, tanks and other implements of war. The immediate adoption of all possible conservation measures is imperative to prevent curtailment of necessary war production.

The War Production Board urgently requests the cooperation of management and labor to overcome existing waste, adopt conservation measures, and thereby help maintain vital war production at maximum levels. For this purpose, several suggested conservation measures are brought to your attention:

Stop gas wastage from leaky hose and apparatus in bad repair.

Close valves on cutting and welding torches while work is being adjusted and during rest periods. Use all the gas in each cylinder before connecting a new one.

Do not use higher oxygen pressures than necessary to do the job. Follow manufacturer's recommendations as to working pressures and sizes of nozzles and tips.

Curtail less essential oxy-acetylene uses, such as the use of oxygen and acetylene for heating purposes. Substitute other gases more readily available.

Return promptly empty cylinders with caps. Do not abuse cylinders.

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Donald Nelson
Chairman

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Section 3. Other nominations for office may be presented from the floor at the annual meeting.

Section 4. Voting for officers shall be by written ballot.

ARTICLE VIII

Miscellaneous

Section 1. The Executive Committee is empowered to appoint committees for special purposes.

Section 2. The Chairman shall be, *ex-officio*, a member of all committees.

Section 3. Proposals for amendment to these By-Laws may be submitted in writing at any regular meeting of the Chapter, and, if approved by a majority of the voting members present at the meeting, shall be submitted at the next regular meeting of the Chapter for final ballot. If approved by two-thirds of the votes cast, the amendment or amendments shall become a part of the By-Laws. No such amendments are valid, however, if they conflict with the Constitution or the By-Laws of the AMERICAN WELDING SOCIETY.

Section 4. These By-Laws shall go into effect immediately upon their adoption by a vote of the Chapter, such adoption requiring at least a two-thirds vote of the members voting.

ARTICLE IX

Dues

Section 1. The annual dues shall be $——— payable at the first meeting during the academic year. (Some Chapters will find it unnecessary to have dues, the refund from the Society Headquarters being sufficient to cover all expenses.)

MEMBERS IN ARMED FORCES

The AMERICAN WELDING SOCIETY would like to have a record of all of its members who are in any branch of the Armed Forces. The Secretary of the SOCIETY would appreciate if these members would supply the SOCIETY with information as to type of service, rank, date of joining and any other interesting information.

In particular, the SOCIETY would like to maintain contact with the members and suitable addresses, if possible, should be included.

PROFESSIONAL PERSONNEL

The Committee on Scientific Research Personnel of the War Manpower Commission is preparing a roster of professionally qualified civilians who are engaged full time in research in the development of instruments of war or associated activities, or on medical problems important to the war effort. It is anticipated that this roster will be used as one of the basis for obtaining occupational deferments for fully qualified scientific and professional personnel engaged in essential research activities.

It is desired that Navy contractors provide the names, home addresses, fields of specialization and salaries of those of their personnel who are engaged in the research activities described in paragraph one. This information should be sent directly by the employer to Dr. Leonard Carmichael, National Roster of Scientific and Specialized Personnel, 1006 U St., N. W., Washington, D. C.

HANDBOOK FOR THE WELDING AND CUTTING OPERATOR

As a helpful step in instructing users of the oxyacetylene welding and cutting process how to prolong the life of their equipment, the International Acetylene Association has prepared a convenient, 20-page, pocket-size booklet entitled, "Handbook for the Welding and Cutting Operator." Written in an easy-to-understand style, it contains a list of concise do's and don'ts for the man who welds the blowpipe and a wealth of other helpful information and suggestions on the care and maintenance of blowpipes, regulators and welding and cutting accessories.

A copy of this handbook should be placed in the hands of every welding and cutting operator. It may be obtained in reasonable quantities without charge from any manufacturer of oxygen, acety-

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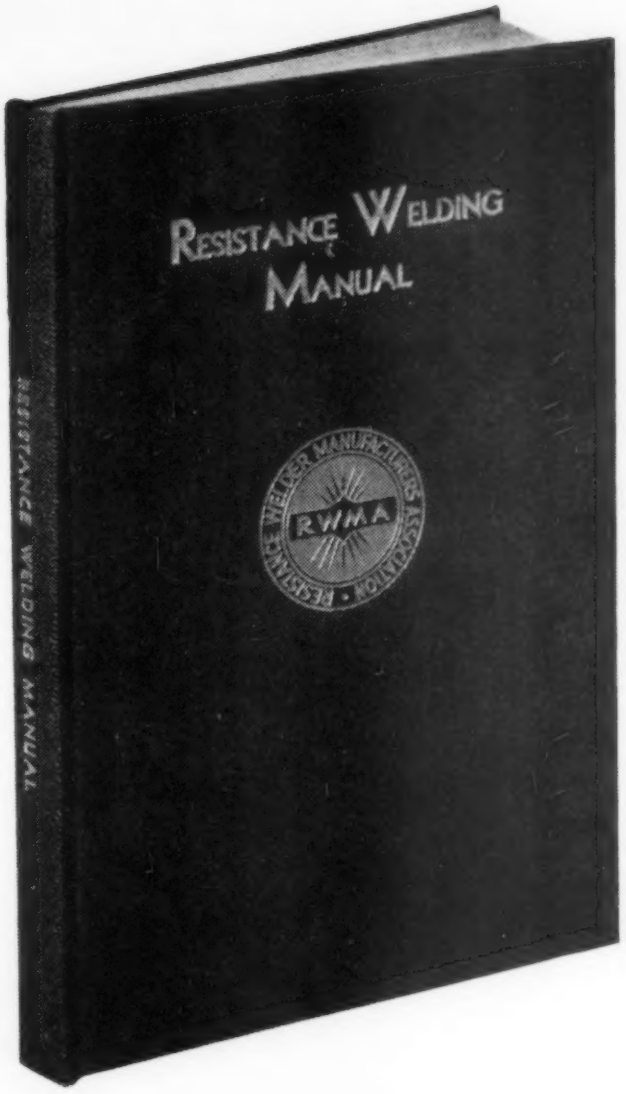
SAYS FRANK HAMMONS OF INDIANAPOLIS
"YOU SEE THE CHARGE"
● "Yes, sir, I've had my Sight Feed over four years now. And I figure it's CUT my acetylene costs about three-fourths. Mind you I'm not *tight*, but I am *thrifty*—for, after all, I'm in business to make money. Too, I like Sight Feed's *visible* carbide supply. It never lets me down in the middle of a big job. And Sight Feed is *flexible*—handles *any* torch at *any* pressure! In short, it's just a good all 'round piece of equipment I'd recommend to my best friend."
THE SIGHT FEED GENERATOR CO.
Sales: Richmond, Ind., Factory: W. Alexandria, O.

JUST PUBLISHED

The first and only

authoritative reference book

covering all phases of resistance welding exclusively.



6 Chapters
286 pages
205 tables, charts and illustrations

The RESISTANCE WELDING MANUAL was written and prepared by a group of resistance welding experts under the joint sponsorship of the Resistance Welder Manufacturers' Association and the American Welding Society.

All of the material in the book was originally included in the second (1942) edition of THE WELDING HANDBOOK published by the American Welding Society.

Realizing the urgent demand for resistance welding information and data, the Resistance Welder Manufacturers' Association, by arrangement with the American Welding Society, has now separately published all of the HANDBOOK material dealing with resistance welding. By this arrangement, it is now possible to obtain all of the resistance welding material without the necessity of securing the entire WELDING HANDBOOK.

This material has not been condensed or abridged in any manner.

Price $2.50 postpaid

THE RESISTANCE WELDER MANUFACTURERS' ASSOCIATION

505 ARCH STREET PHILADELPHIA, PENNSYLVANIA

lene, carbide or welding and cutting apparatus and supplies. Or, write directly to the International Acetylene Assn., 30 E. 42nd St., New York, N. Y.

RATINGS SHOW USABLE WELDING CURRENT

Recently announced by Harnischfeger Corporation, manufacturers of P & H welding machines, both d. c. and a. c., the new "WSR" method of rating welding current output promises to be an important progressive step in the industry. By this system, the buyer or user is shown precisely at a glance the exact minimum and maximum limits of a machine's usable welding current range. "WSR" (Welding Service Range) ratings have but one primary function—to eliminate all guesswork in determining the loads a machine can or cannot handle. They are merely a finer development of the present method of rating and, according to engineers of P & H, the only company using the system today, they can be applied to any make of welder. Up to now, they say, the practice has been to give the machines a nominal rating only, such as 300 or 400 amp., for example. The buyer understood according to industry standards, that a machine would deliver its nominally rated capacity for one hour against a fixed resistance load, depending upon the size of the machine, without exceeding the allowable temperature increase. He was further assured by prescribed standards that it had a reserve current capacity of not less than 25% in excess of nominal rating. Beyond this general guarantee of current delivery, it has never been the practice to define clearly exact high and low output limits. Consequently, the buyer had to discover for himself the machine's actual ability and until he did so, was unable to make an equitable comparison of values with other machines on a delivered performance basis. While the present rating system may be adequate in many installations, the advantages of "WSR" are immediately obvious, especially under present conditions restricting availability of equipment. In many cases, a precise knowledge of a machine's actual greater capacity might have avoided the apparent need for larger equipment. "WSR" ratings will eliminate such misunderstanding and confusion, and since their adoption involves no changes in basic welder design, but simply a new amperage calibration plate, it is not unlikely that other leading manufacturers will adopt the system. A brochure on "WSR" ratings is available on request from the Welder Division, Harnischfeger Corporation, Milwaukee, Wis.

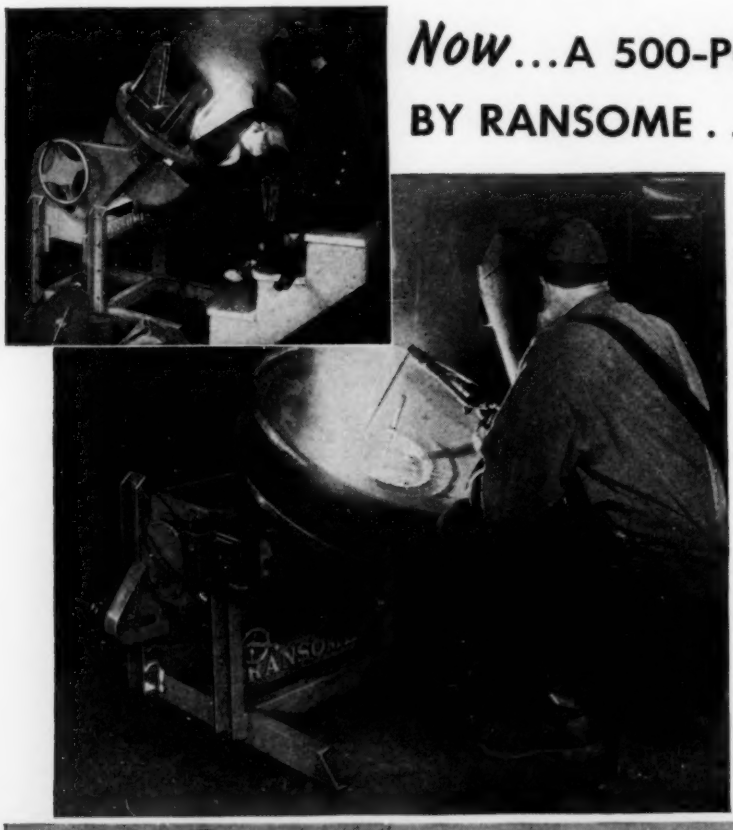
LIST OF STANDARDS

On May 28, 1943, the American Standards Association announced publication of its new List of American Standards which will serve as a useful reference piece to the engineering and purchasing departments of manufacturing firms.

More than 600 standards are listed, 94 of which represent new and revised standards approved since the last (August 1942) issue. These are marked with an asterisk.

Standards are listed by subject and cover civil, mechanical, electrical, mining, chemical and other engineering fields as well as metals and materials, specifications of interest to the textile, wood, pulp and paper industry, methods of test for the finished product, dimensions, etc. They reach into every important engineering field and serve as a basis for many municipal, state and Federal regulations. By frequent review these standards are kept abreast of new developments in the fields to which they relate.

Annual Meeting
Chicago
HOTEL MORRISON
Oct. 18-21



Now...A 500-POUND WELDING POSITIONER BY RANSOME... *Motor or Hand-Operated*

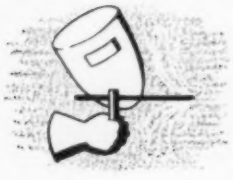
Here's a versatile machine that will help you do better welding faster . . . on a wide variety of work. It's top-quality equipment and ideal for women welders.

- **Table top tilts to 135° from horizontal (45° beyond vertical).**
- **T-slots in table top simplify clamping of work.**
- **Handles a 500-lb. load with a 6-inch center of gravity and a 6-inch eccentricity.**
- **Cut gears are used throughout.**
- **Clutch permits free rotation of table top, by hand.**
- **Available with elevating base, to give 42 inches from floor to table top.**
- **On motorized machine, Reeves variable-speed drive gives range up to 1 r.p.m. for table rotation. Choice of power or hand-wheel tilting.**

Other Ransome Positioners cover a range of types and sizes up to 20 tons. ***Write for literature*** ... and for recommendations to meet your particular needs.

Ransome WELDING POSITIONERS
INDUSTRIAL DIVISION • RANSOME MACHINERY COMPANY • DUNELLEN, NEW JERSEY

PAGE *Welding* ELECTRODES



Of course **PAGE** developed a new electrode for welding armor . . . Important as that may have been to tank production, it is just as vital—to those who weld Stainless Steel—that **PAGE** also developed a *complete* range of electrodes for this purpose. In fact, no matter what Stainless Steel you are welding, **PAGE** can supply you with electrodes that deposit, in the weld, metal that equals the Stainless you are using. That is something worth checking into with **PAGE.**

PAGE STEEL AND WIRE DIVISION

Monessen, Pa., Atlanta, Chicago, Denver, Los Angeles, New York, Pittsburgh, San Francisco, Portland

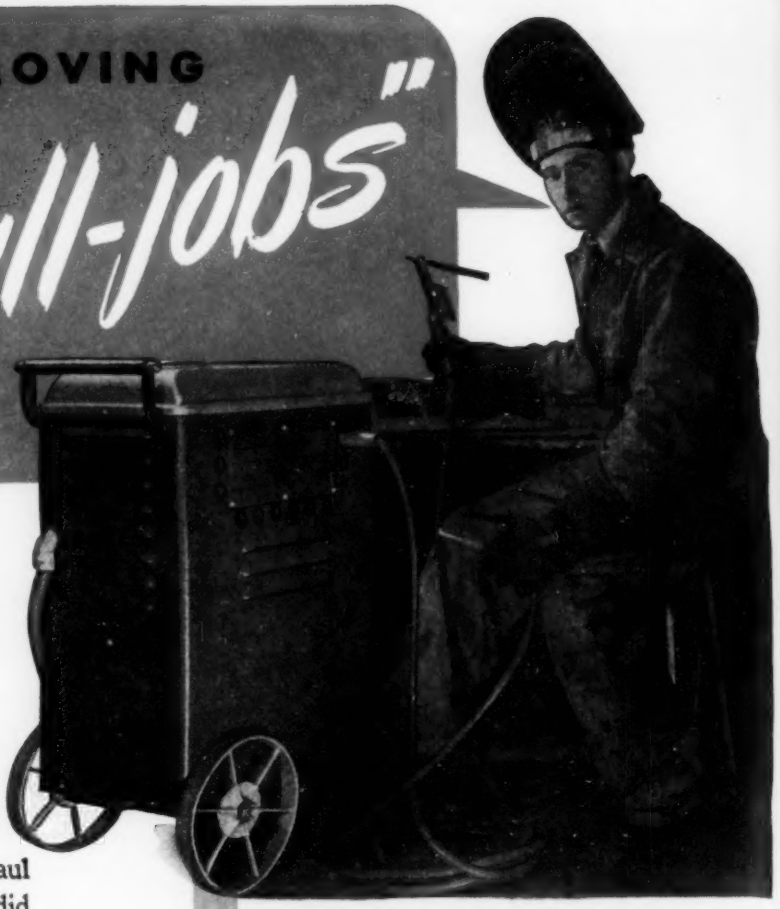
AMERICAN CHAIN & CABLE COMPANY, Inc.

BRIDGEPORT • CONNECTICUT

ESSENTIAL PRODUCTS . . . TRU-LAY Aircraft, Automotive, and Industrial Controls, TRU-LOC Aircraft Terminals, AMERICAN CABLE Wire Rope, TRU-STOP Brakes, AMERICAN Chain, WEED Tire Chains, ACCO Malleable Castings, CAMPBELL Cutting Machines, FORD Hoists, Trolleys, HAZARD Wire Rope, Yacht Rigging, MANLEY Auto Service Equipment, OWEN Springs, PAGE Fence, Shaped Wire, Welding Wire, READING-PRATT & CADY Valves, READING Electric Steel Castings, WRIGHT Hoists, Cranes, Presses . . . *In Business for Your Safety*

A REAL WORK-MOVING

"Jack-of-all-jobs"



SAYS JOB SHOP OPERATOR OF HIS

A-C WELDER

Like most every other job shop operator, Paul Ehrhardt is swamped with jobs he never did before. Things people used to throw away, he now welds for further service . . . tractor cleats, sprockets, gears, housings, levers, lawn mower parts, etc. In addition, he fabricates parts for war industry, and at night teaches welding . . . a schedule that leaves no leeway for gadget-fussing or time out for maintenance. For that kind of service he switched to a-c welding.

From his Westinghouse All-purpose A-C Welder he gets the speed he needs—20% to 30% faster welding. He has no arc blow or maintenance to contend with, and he can turn out consistently better welds. Add to that, ample capacity for all types of job shop work, lower first and operating costs, simplicity of control, availability, and you have Mr. Ehrhardt's reasons for selecting the Westinghouse A-C Welder.

Before adding to or replacing present equipment in your shop, look into Westinghouse A-C Welders. Ask your Westinghouse Distributor or write for A-C Welding Booklet B-3136, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N.

J-21279

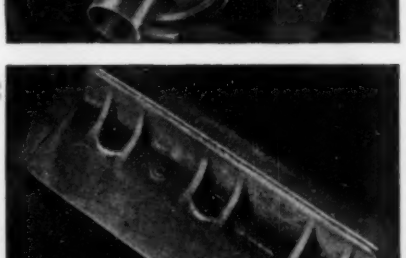
Paul Ehrhardt, Ehrhardt Welding Co., McKeesport, Pa., welds for Victory during the day . . . teaches welding at night on his Westinghouse All-purpose A-C Welder.

EXAMPLE:

FABRICATES war products . . . makes vacuum-tight welds on housings for vacuum systems using Westinghouse DH and SW electrodes.

EXAMPLE:

MAINTAINS vital equipment. Hard-facing tractor cleats with Westinghouse Hardentough electrodes lengthens cleat life 3 to 5 times.



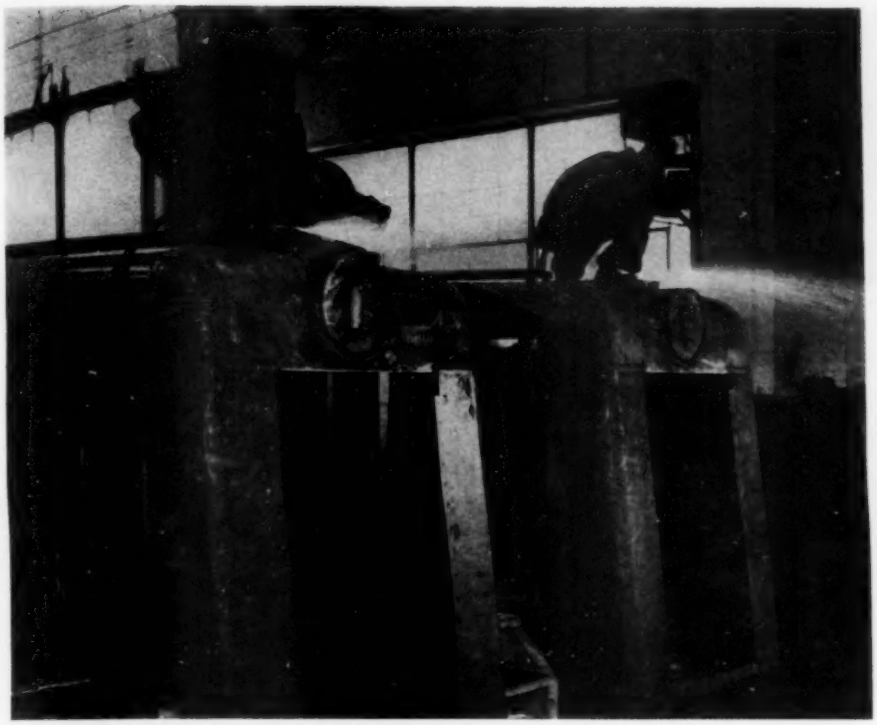
EXAMPLE:

REPAIRS cast steel bulldozer drive sprockets. Break was burned out, pre-heated and welded with Westinghouse FP electrodes.

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

A-C WELDERS



WELDED LOCOMOTIVES

Sparks fly from their portable grinding wheels as these operators finish smooth weld seams of fabricated engine hoods for two Diesel-electric locomotives in manufacture at General Electric's Erie Works.

1943 A.S.T.M. SYMPOSIUM ON RADIOGRAPHY

This 265-page book issued in May 1943, by the American Society for Testing Materials includes 18 technical papers presented by outstanding authorities. The major part of the book includes the technical contributions in the 1942 Symposium, but an important part is the collection of 1936 papers, several of which have been extensively revised, some condensed. Issued through the work of a special group of A.S.T.M. Committee E-7 on Radiographic Testing the Symposium has as its basic purpose the development of better understanding of radiographic tests and their significance on the part of both the consumers and producers of materials.

There are extensive contributions on principles of radiography, foundry applications, miscellaneous applications, gamma-ray radiography with instructions for using radium and the problem of inspection. Other topics covered include applications to production problems, welds and weldments, magnesium aircraft castings, correlation of mechanical properties and radiographic appearance of magnesium alloy castings, million-volt portable unit, high-voltage X-rays in the boiler shop, welded high-pressure power plant piping, apparatus used in radium radiography, exposure meter, study of cassette design, precision radiography, X-ray film evaluation, industrial X-ray protection and recommended A.S.T.M. industrial radiographic terminology.

Special coated stock has been used to bring out the some 175 illustrations used in the book. Copies of this publication in red cloth binding, 6 x 9 in. can be obtained from A.S.T.M. Headquarters, 260 S. Broad St., Phila., Pa., at $4.00 each.

TIPS ON ARC WELDING

The Ergolyte Mfg. Co. of Philadelphia, Pa., manufacturers of Ergolyte a.-c. arc welders and supplies, is offering an attractive chart called, "Hot Tips on Arc Welding," in a size 11 x 14 in., suitable for hanging on the bulletin board of a shop.

The principle do's and don'ts to remember for safety, speed and economy are described and pictured in nine panels.

Copies are available, free, by writing to the company on your business letterhead.

SILVER BRAZING BULLETIN

A very interesting and instructional bulletin has just been completed by Handy & Harman, 82 Fulton St., New York City, giving information regarding design of low-temperature silver-alloy brazed joints.

ARMY-NAVY "E" TO UNITED WELDING CO.

The United Welding Company, Middletown, O., one of the largest contract welders in the Middle West, was honored by the Army and Navy on May 25th when the "E" was presented to them.

The United Welding Company are pioneers in the welding industry, having a record of over 15 years of satisfactory service to many important and exacting manufacturers. They are one of the largest and best-equipped plants specializing in steel fabrication to order. Their Uni-Weld construction has produced a new era in machine building and made possible improved designs in many types of equipment, such as press frames, machine bases, columns, arms, brackets, pressure vessels and many others.

WESTINGHOUSE WELDERS FOR JOB SHOP WORK

4 ways to better welding

FOR SHOP MAINTENANCE AND LIGHT WORK

Model WT-1C—100 amperes. Current range, 20 to 140 amperes. Built-in capacitor (optional). Built-in breaker protection. Easy to move.

ALL-PURPOSE WELDER

Model WT-4C—200 amperes. 27-step current adjustment from 20 to 250 amperes permits using wide variety of electrodes. Built-in capacitor (optional) and Nofuze "De-ion" Circuit Breaker.

NEW D-C WELDER WITH ARCONTROL

Single, pre-set current adjustment. Lots of capacity to handle all kinds of work. No drop-off after warming up. Simple adjustments. 200, 300 and 400-ampere models.

COMPLETE LINE OF WELDING ELECTRODES

Westinghouse electrodes are designed for fast production of high-quality welds with a-c or d-c on carbon steels, cast iron, stainless and alloy steels, sheet metal and special applications. Strike easily and have high deposition efficiency.

* * *

Write for latest a-c and d-c welding literature. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N. J-21279

Westinghouse

PLANTS IN 25 CITIES... OFFICES EVERYWHERE

WELDERS

ALUMINUM CASTINGS SALVAGED

The adoption of the atomic-hydrogen arc-welding process to repair imperfect aluminum castings has resulted in the saving of much time and critical material at the plant of a prominent Ohio casting manufacturer. Since this process has been in use at this plant, rejection of repaired castings has been less than 1%, in spite of the fact that all castings are subject to rigid X-ray inspection.

Courtesy General Electric Co

An Imperfect Casting Being Welded

Prior to being repair welded, the castings are preheated in a furnace which adjoins the welding booth. Metal of the same analysis as the base metal in the casting is then deposited by a welding operator who has passed special Air Corps qualification tests. After the completed welds are ground flush with the casting surface, it is impossible to detect the weld outline even by X-ray inspection and physical testing.

Experience at this plant has shown that in almost every case imperfect castings can be salvaged with absolutely no sacrifice of quality, regardless of the size of the original imperfection. The company's investment in equipment was saved in less than three months.

GORDON JOINS DETROIT ELECTRONIC LABORATORY

John D. Gordon, formerly General Manager of the Taylor-Winfield Corporation has announced the formation of Detroit Electronic Laboratory with headquarters at 10345 Linwood Ave., Detroit, Mich.

The new company which Mr. Gordon will direct as General Manager is concentrating on the development and manufacture of special purpose electronic tubes. Among the special tubes under development is a line designed primarily for control equipment for resistance welding.

In recognition of the difficulty in obtaining ignitron tubes at the present time due to the fact that they contain large amounts of critical materials, Detroit Electronic has also announced a "Victory Repair Service" for such tubes—of vital importance in the resistance welding of aircraft, etc.

The new service, designed to conserve such critical materials will also eliminate long delays in obtaining new tubes.

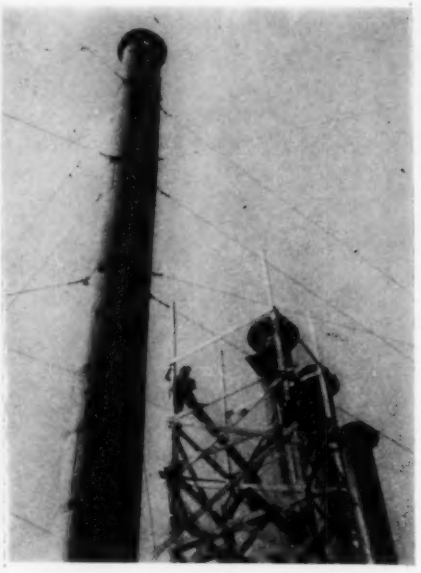
According to company officials, all such repaired tubes will be guaranteed as in first-class condition. Among the tubes which Detroit Electronic is set up to repair are General Electric GL and GF series and Westinghouse WL series, ranging from 150 to 1200 kva.

Cost of repairing tubes varies with the type of work to be performed, it is understood, while—if tubes are beyond repair—Detroit Electronic reimburses the shipper for the scrap value of the tube.

SPEEDING ERECTION OF BOILER STACKS

All-welded construction speeded the erection of two urgently needed boiler stacks recently at a large southern manufacturing plant. The stacks, each 150 ft. high and 5 ft. in diameter, were erected in one-third less time than normally would be required.

Fabricated from low carbon,, $^1/_4$-in. steel sheets, the stacks were built in 5-ft. sections weighing approximately 850 lb. For the first 100 ft. of installation, two sections were welded together in the shop,



One of the Two 150-Ft. Boiler Stacks Fillet Welded

then erected as a single unit and welded in position. During the last 50 ft., however, each 5-ft. section was mounted separately, to simplify handling operation.

All joints were fillet-welded, approximately 1200 lb. of $^3/_{16}$-in. electrodes being used on the two stacks.

Although the height of the stacks and their inaccessible position necessitated locating the engine-driven welders 400 ft. from the work, the operators stated that at no time did they encounter the slightest difficulty in striking or maintaining the proper arc.

The contractors were E. McLaughlin & Sons, of Richmond, Va., and the welding equipment was supplied through the Arcway Equipment Co., General Electric welding distributor.

NEW MANUAL OF WELDED HEAT EXCHANGER TUBING

Due to the huge demand for heat exchangers, condensers and other types of heat transfer apparatus in the construction of new equipment for the production of synthetic rubber and of aviation gaso-

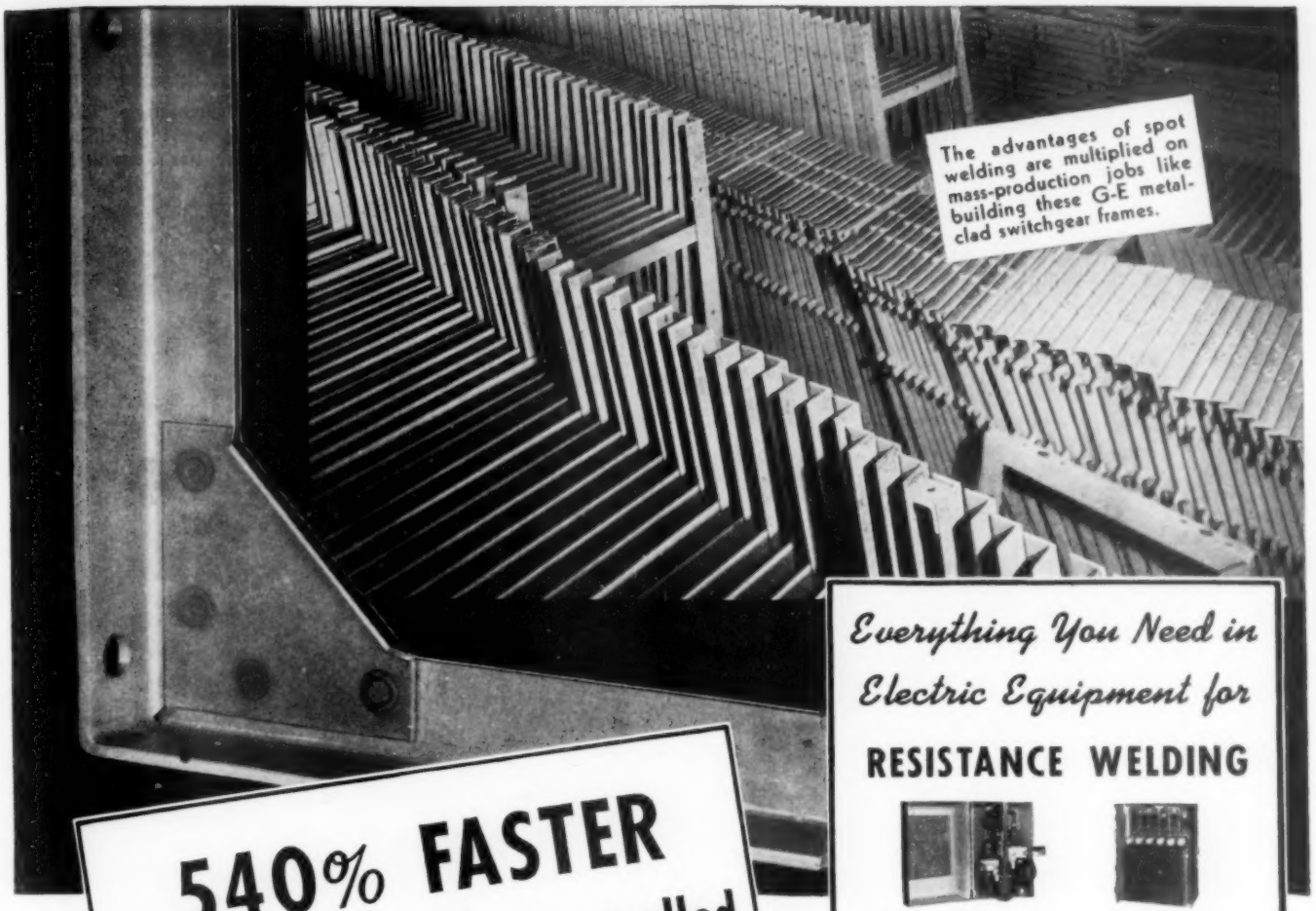
WELDING ENGINEER

For electronics industry to specialize in problems of resistance welding. Must have a good technical background in Metallurgy and Resistance Welding, plus a thorough knowledge of welding equipment and circuits. Applicants should submit detailed information regarding training, work experience, and family status. Workers now employed in essential activities will not be considered.

RCA VICTOR DIVISION
OF
RADIO CORPORATION OF AMERICA
LANCASTER, PA.

SPEED UP WITH
SHAWINIGAN
CARBIDE

SHAWINIGAN
SHAWINIGAN PRODUCTS CORPORATION
EMPIRE STATE BLDG., NEW YORK



The advantages of spot welding are multiplied on mass-production jobs like building these G-E metal-clad switchgear frames.

540% FASTER with Electronically Controlled SPOT WELDING

SPOT-WELDING the thousands of corners for G-E switchgear enclosures speeded production 540 per cent over riveting; 375 per cent over bolting. Spot welding eliminated punching holes, inserting rivets or bolts, and the riveting or bolting operations—saving time, material, and man power.

Electronically controlled resistance welding is speeding the construction of light-metal and stainless-steel aircraft. It's replacing soldering, too, saving tin and time. Joining like or unlike metals and alloys. Giving dependable, *consistent* results. Making gastight seams. Helping speed the training of new operators. Resistance welding is ideal for high-production operations on heavy or light work, portable or fixed.

Whatever your application, be sure to specify G-E electronic control and other electric accessories. For further information, contact any G-E office, or your resistance-welder manufacturer or agent. Or write General Electric, Schenectady, N. Y.

Everything You Need in Electric Equipment for RESISTANCE WELDING

Electronic controls for spot and seam welders

Electronic weld and sequence timers

Weld-recorders—to record electrical input of EVERY weld

Electron tubes for all purposes

Cables and instruments

Air circuit breakers and welding transformers

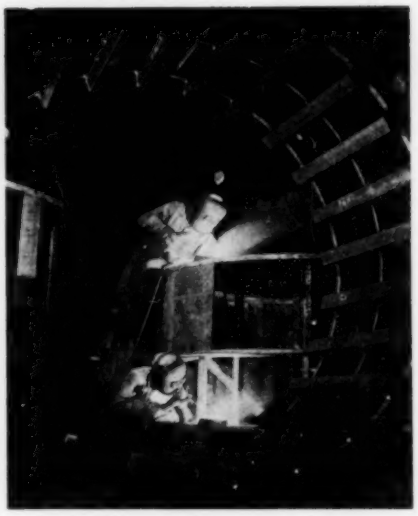
Capacitors for power-factor improvement

Motors and control

Speed Production Electronically

GENERAL ELECTRIC

line, there has been a very large expansion in the manufacture of welded steel tubing for heat exchanger and condenser use. The *Manual of Welded Steel Tubing for Heat Exchanger and Condenser Use* has been prepared to furnish complete information on this product to manufacturers and users of all types of heat transfer equipment. One section is devoted to an illustrated description of the welded tube manufacturing process, with special reference to the numerous tests that are used for checking and controlling the quality of all welded tubing that is produced for this application. Also included is a discussion of the method used to identify each welded tube manufacturer's product, by means of an individual symbol on every length of this type of tubing. For the purpose of facilitating the placing and filling of orders for heat exchanger tubing, suggestions are made as to the information which should be given when ordering. A chart shows the dimensions of those standard sizes of welded tubing which are within the range of standard sizes commonly used for heat transfer applications. Later portions of the manual furnish fabricating data and extensive tables of tube properties, for use in calculating surface areas, carrying capacities, displacements, etc. Copies are obtainable from Formed Steel Tube Institute, 1621 Euclid Ave., Cleveland, Ohio.

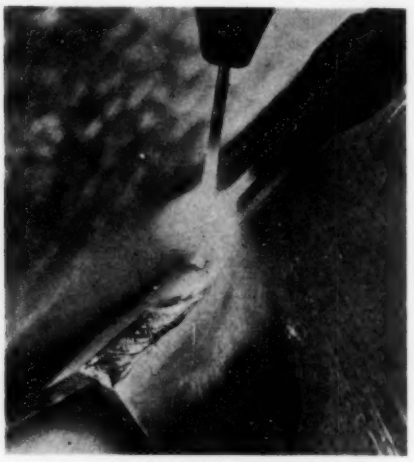


POWER FOR WAR PLANTS

A team of welders seals the joints of a frame for a turbogenerator at the East Pittsburgh Works of the Westinghouse Electric & Mfg. Co. When completed, this frame will be a part of the generating equipment to turn out electric power for war-busy industrial plants. The big circular "ladder" in the foreground is a frame for a 4500-hp. electric motor.

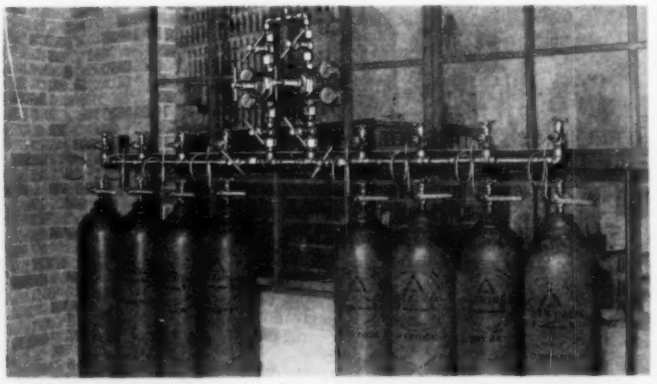
TRAINING FILM "THE INSIDE OF ATOMIC-HYDROGEN ARC WELDING" NOW AVAILABLE

A new all-color sound movie "The Inside of Atomic-Hydrogen Arc Welding" has been announced by the General Electric



The Size and Shape of the Molten Pool Are the Operator's Guides to Good Welding. On a Corner Joint, such as This, the Width of the Pool Should Be About Twice the Thickness of the Work and the Surface Should Be Well Rounded. View from "The Inside of Atomic-hydrogen Arc Welding"

Is this YOUR Cleaning Problem?
Safely Preparing Alclad for Resistance Spot Welding
Many aircraft plants will tell you that the SAFEST, most effective way to clean Alclad or other aluminum alloys before spot welding is the Oakite Surface Preparation Process.
Employing Oakite materials specially designed to thoroughly, speedily remove oil, grease, stamping compounds, identification paint and oxide film, it produces low surface resistance . . . enables operators to make MORE UNIFORM welds and turn them out on a FASTER schedule! Special Technical Bulletin giving details FREE to executives responsible for this work. Write for it today.
OAKITE PRODUCTS, INC., 18E Thames St., NEW YORK
Technical Service Representatives Conveniently Located in All Principal Cities of the United States and Canada
OAKITE
Buy Bonds for Victory
CLEANING



BRASS MAKES BULLETS

REGO Gas Plant Equipment to be safe, must be made of brass and other critical metals.

Conserve equipment—You may not get more.

The BASTIAN-BLESSING Co.
4241 W. PETERSON AVE. CHICAGO
Pioneers and Manufacturers of Precision Equipment for Using and Controlling High Pressure Gases

A 100% RECORD

Awards on May 8th, 1943 to two plants in Kenosha, Wisc., completed this 100% record for The American Brass Company.

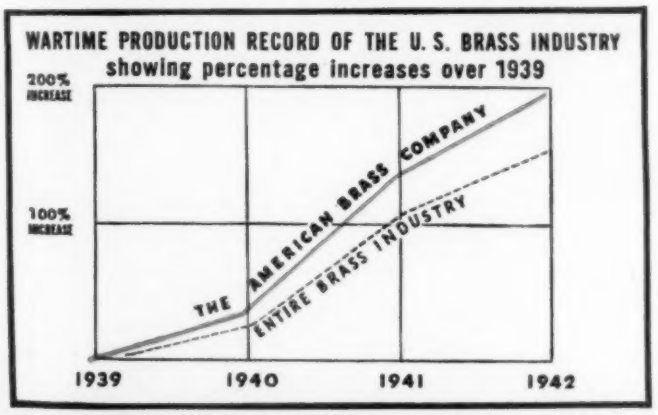
ALL TEN AMERICAN BRASS CO. PLANTS IN U. S. A. HAVE EARNED RIGHT TO FLY ARMY-NAVY "E" FLAGS

This is the story in terms of war production

Our Connecticut plants were among the first in the brass industry to receive the coveted "E" Award for outstanding production of war materials. Since then *all* our plants, including those in the States of Michigan, Wisconsin and New York, have been similarly honored.

As the largest fabricator in the copper and brass field, The American Brass Company is keenly aware of its responsibility and its opportunity to serve the cause of the United Nations.

Since 1939, production has been tripled, with virtually every pound today going for war purposes.



This chart*, based on 1939 peacetime production, shows the rapid swing into all-out war production, both by the copper and brass fabricating industry and The American Brass Company (not including Government-owned plants). All-time production records have been continually broken ever since the National Defense Program was initiated in 1940.

*Based on compilations of The American Bureau of Metal Statistics

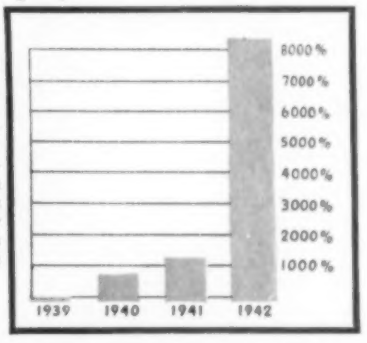
This record was accomplished by close cooperation between management and labor . . . careful planning for rapid conversion to wartime operations . . . intensive training of new personnel . . . plus efficient utilization of existing and new plant equipment.

Detailed figures, of course, cannot be revealed, but The American Brass Company is consistently breaking all previous volume records. In addition to its U. S. plants and that of a Canadian subsidiary, Anaconda American Brass Ltd., the company's production also embraces three plants operated for the United States and Canadian Governments.

Shipments this past January were the largest in the company's history. March exceeded January. The first quarter of '43 was by far the greatest tonnage quarter in the records of the company.

PRODUCTION OF COPPER ALLOYS FOR AMMUNITION by The American Brass Co.

This chart shows the vast increase in production of copper-base alloys directly earmarked for ammunition in plants operated by The American Brass Company. This is one of the most vital needs for copper and brass. Tremendous quantities are required for all types of ammunition.



The American Brass Company is proud indeed that all the plants it operates in the U. S. A. have won the honor of flying the Army-Navy "E" for excellence in production. But it is even prouder of the organization and the will-to-produce that have made this record possible . . . *and will keep it going.*

431B4C

THE AMERICAN BRASS COMPANY

ANACONDA

Subsidiary of *Anaconda Copper Mining Company*

BUY ALL THE BONDS YOU CAN AFFORD . . . TURN IN ALL THE SCRAP YOU CAN FIND

Company to help in the training of men and women welding operators using this process in war industries. The movie is in two parts and is available to public, private and industrial welding schools and other groups.

Produced by the Raphael G. Wolff Studios, Hollywood, under the direction of the General Electric welding laboratories, the new film follows the very successful pattern of "The Inside of Arc Welding" films released by G. E. last year and of which more than 2800 reels are now in regular use.

Each of the two parts of the new film employs colorful charts, animation, demonstrations by expert operators, close-ups of the "singing" atomic-hydrogen arc in action, as well as examples of good and bad welding. The films are ten minutes in duration and can be used on sound-equipped 16-mm. projectors only.

Part One of the new film describes and illustrates the fundamentals of atomic-hydrogen welding. It shows how to regulate the welding current and the hydrogen supply; how to adjust the electrode holder and the tungsten electrodes; and how to recognize and correct improper adjustment.

Part Two shows proper technique for principal types of joints; how to control the molten pool; and how to recognize and correct improper welding conditions. Particular emphasis is given these four factors—current setting, speed of travel, size of arc and the contact of the arc with the work.

The film may be obtained for single showings, or bought at *print* cost, by writing General Electric's Visual Instruction Section, Schenectady, N. Y., or the nearest G. E. office or welding distributor.

NEW ELECTRODE INDEX SIMPLIFIES COMPARISON

A new electrode comparison chart published by Air Reduction Co. helps to simplify buying of competitive welding electrodes. The chart details the principal A.W.S. and A.S.T.M. electrode classifications and indicates which electrodes produced by twenty leading manufacturers meet the different requirements.

The buyer can use this chart to determine what brands of electrodes fall within a specified A.W.S. and A.S.T.M. category, as well as to learn what alternate brands might be used successfully should a specified electrode not be available.

Free copies of this helpful comparison chart may be secured by writing to Mr. G. Van Alstyne, Air Reduction Co., 60 E. 42nd St., New York, N. Y.

WOMEN WORKERS

For every nine men working in the yards of The New England Shipbuilding Corporation at South Portland, Me., there is one woman who, in many cases, is "doing a man's job," the War Manpower Commission said today. Ten per cent of the more than 26,000 workers in the yards are women. Many of them are in the offices, but most of them are on work that puts callouses on the hands. Among them are riveters and welders but many of the huskier ones are on jobs that call for the brawn it was once taken for granted only the male could provide. Before the end of the year the management expects to have on its pay roll many more women. Even now many women are among the "job instructors"—and men as well as women are sent to them for guidance.

SERVICING SAFETY EQUIPMENT

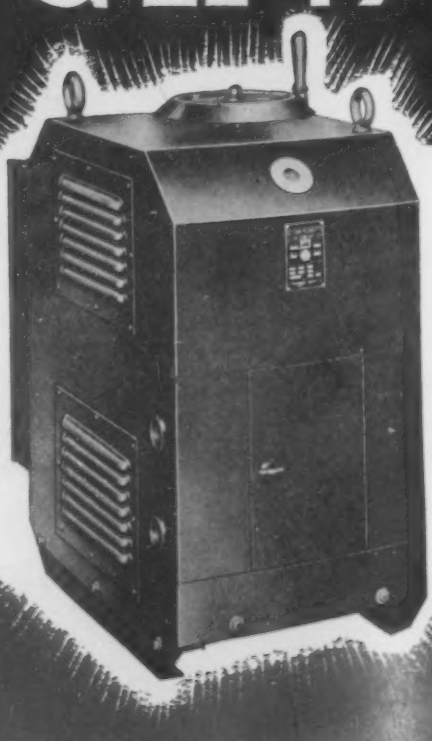
Closely paralleling the rapidly increasing acceptance of welding as a modern production and maintenance tool has been the industry's concern for the safety of its highly skilled workers. Helmets, shields, goggles and protective clothing today are standard equipment. Equally important from the standpoint of insuring worker

Announcing the **NEW**

an EXTRA-HEAVY DUTY WELDER for CONTINUOUS OPERATION

... Power Factor Corrected

G-R 49



Here is a powerful machine built with an oversized core working at low flux densities to provide a generous safety factor *for continuous welding loads.* Model 49, with a welding range of 100 to 675 amperes, has been especially designed to work around the clock, week after week.

Cool in operation (forced ventilation is standard), the G-R 49 handles rod varying from 1/8-in. to 3/8-in. with only a twist of the hand wheel; completely meets every demand for a manually-operated machine for the fabrication of heavy plate.

GLENN-ROBERTS COMPANY

1009 FRUITVALE AVENUE
OAKLAND, CALIFORNIA

2107 ADAMS STREET
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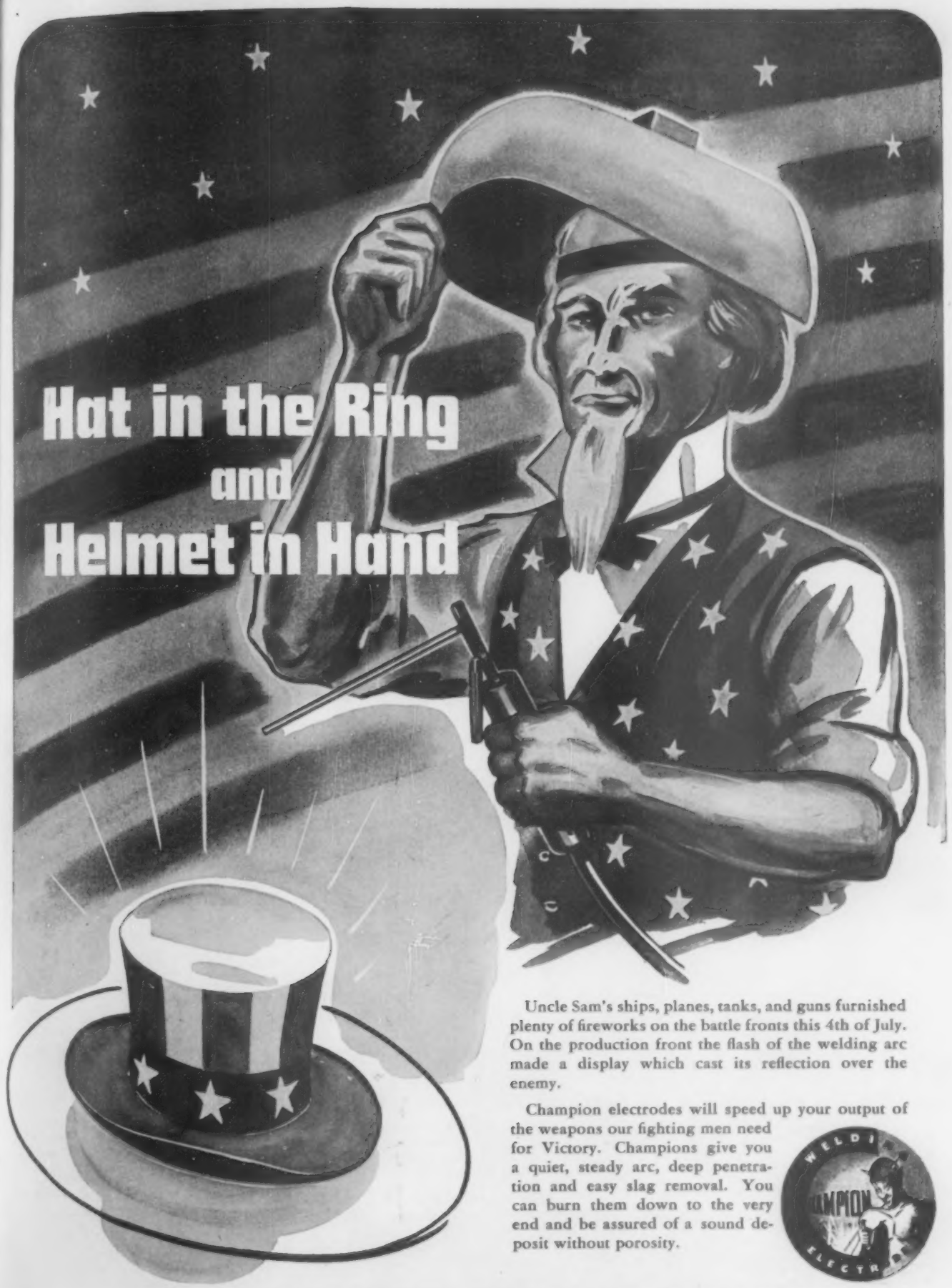


Uncle Sam's ships, planes, tanks, and guns furnished plenty of fireworks on the battle fronts this 4th of July. On the production front the flash of the welding arc made a display which cast its reflection over the enemy.

Champion electrodes will speed up your output of the weapons our fighting men need for Victory. Champions give you a quiet, steady arc, deep penetration and easy slag removal. You can burn them down to the very end and be assured of a sound deposit without porosity.

THE CHAMPION RIVET COMPANY

11400 Harvard Avenue, CLEVELAND, OHIO

EAST CHICAGO, INDIANA

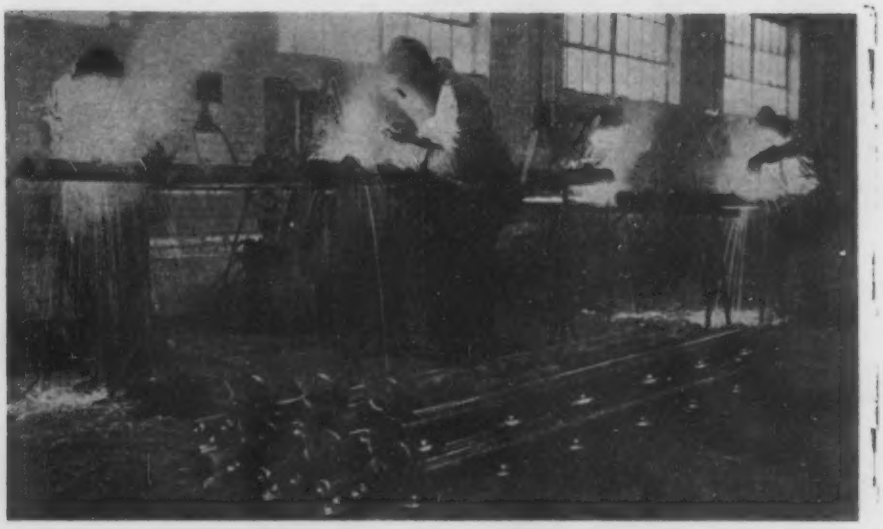
protection and prolonging equipment life are the care and maintenance of safety devices. A 5-page Special Service Report on this subject, just published by Oakite Products, Inc., New York, N. Y., is therefore particularly timely.

After pointing out the necessity for providing adequate facilities for maintaining personal safety equipment, the report discusses the equipment and materials required for effectively carrying out such a program. The four essential steps in handling maintenance of respiratory and other equipment are described, together with recommendations and detailed instructions.

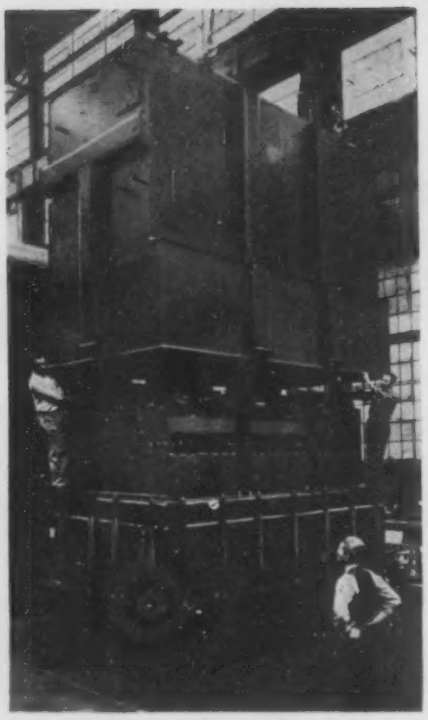
ARC WELDING QUARTET

Striking electric arcs instead of high notes, the arc welding quartet shown in the accompanying busy scene, tune up for rapid weld fabrication of Diesel engine starter headers that go into Uncle Sam's minesweepers.

This striking action photo, taken by 15-yr. old Robert Flori, was submitted by the Flori Pipe Co., St. Louis, Mo.



Courtesy The Lincoln Electric Co., Cleveland, O.



DESIGNED FOR CLOSE QUARTERS

The 37,500-kva. Westinghouse transformer illustrated herewith was engineered to conserve space. The special base fits and encloses the section below the laminations; the main tank is broad at the bottom but smaller at the top so as to equal the base dimensions. After welding the tank to the base, the hermitically sealed unit is filled with oil. Occupying 37% less floor area, the new unit saves 10% in tank metal and 33 1/3% in oil; the overall weight is 19% less than that of a standard forced-oil-cooled transformer.

NOTICE OF NEW ZONE ADDRESS

New York is one of the 178 cities in which the Post Office Department is installing the new zoning system to expedite delivery of mail.

Our zone number is 18. Therefore, in the future, our address should include this number, as follows:

AMERICAN WELDING SOCIETY

33 West 39th Street, New York 18, N.Y.

TURNING ROLLS

A new bulletin, No. 188, illustrating and describing Ransome Turning Rolls for facilitating the welding of large cylindrical tanks and drums, has just been released by the Industrial Division, Ransome Machinery Company, Dunellen, New Jersey. Copies may be obtained by addressing the Company.

MALLORY STANDARDIZED WELDING ELECTRODES

SPEEDIER PRODUCTION
LESS DOWN TIME
BETTER WELDING
LOWER COST

Whatever metals you're resistance welding . . . by spot, seem, flash or butt welding . . . specify Mallory Electrodes. They need redressing or replacement far less often. Write today for your *free* copy of the factual, up-to-date Mallory Resistance Welding Data Book.

P. R. MALLORY & CO., Inc., INDIANAPOLIS, INDIANA • Cable Address — PELMALLO

WELDING -Magic in the World After War

For its part in building strong sinews of war, WELDING has been awarded outstanding honors. But not even the most imaginative mind can estimate the importance of this art in the construction of tomorrow's better world.

Today, engineers and designers are developing plans for home appliances, motor cars and countless other contributions to improved post-war living—plans that will become future realities with the help of the Magic of Welding.

Save Money and Time – Buy A. C. Arc Welders

FOUR SIZES — SIX TYPES

Welding Range . . . 20-300 Amps.

In hundreds of production and maintenance departments of war plants, and repair shops, Emerson-Electric Portable A. C. Arc Welders are stepping up production and effecting "on-the-spot" repairs. . . . Each welder is built to the same high quality standards, for long service, that have characterized Emerson-Electric products for the past 53 years. Approved by Underwriters' Laboratories. *Available on priority ratings.* Write for prices, specifications, and performance data.

THE EMERSON ELECTRIC MFG. CO.
ST. LOUIS—*Branches:* New York • Chicago • Detroit
Los Angeles • Davenport

Emerson-Electric is now engaged 100% in the production of equipment for War or War Plant Use. In addition to regular products are Power Operated Airplane Gun Turrets, Shell Parts and Electric Motors for Aircraft.

EMERSON ELECTRIC

313

MOTORS • FANS • APPLIANCES • A. C. ARC WELDERS

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

NEW A.-C. ELECTRODE

Coincident with their recent announcement of a new line of P & H A.-C. industrial arc welders, the Harnischfeger Corporation has introduced a new all-position electrode designed especially for use with a.-c. transformer welding machines. Suited for all mild steel applications, it is being made in the usual sizes of 1/8, 5/32, 3/16, 1/4 and 5/16 in., and 14- and 18-in. lengths, packed in standard 50-lb. containers. Detailed information and welding procedures are available on request from the manufacturer.

SPRAY TANK

"Speed" is the password with the Speed Spraying Co. of Orlando, Fla. On a recent contract for painting an air base runway for U. S. Army Engineers, a supply unit was quickly and economically built by arc welding. A tank of 450-gal. capacity was fabricated and mounted to a two-wheeled trailer, also constructed by arc welding. Mounting a pump in front of the tank makes possible the filling of the supply tank direct from the barrels of paint.

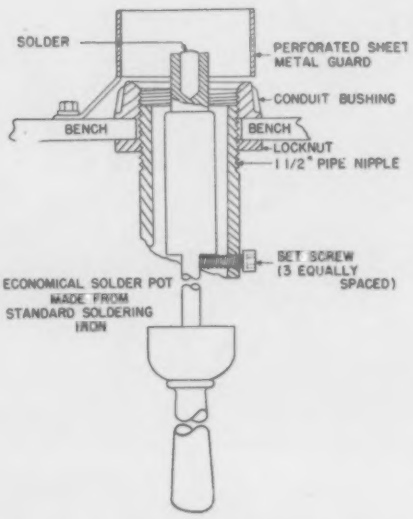
Courtesy The Hobart Brothers Co., Troy, O.

Where previously it had been necessary to return with the spray machine and fill from the barrels and then return to the place of painting, this 450-gal. supply unit now feeds the paint to the spraying machine in large quantities, eliminating time lost by sprayer going back and forth refilling.

SOLDERING IRON MAKES EFFICIENT SOLDERING POT

The use of standard soldering irons especially adapted as small soldering pots has facilitated the production of small instrument-type motors in one of General Electric's Works. Because they present only a very small area for oxidation, the irons are saving materials.

The improvised solder pot, which was developed by R. H. Bainbridge, a foreman, is easily built. A standard medium-size soldering iron tip is faced off flat and drilled with a 1/4-in. diam. hole, 3/4 in. deep. This tip is reassembled to the soldering iron. The iron is then mounted vertically in a hole in the bench so that the tip projects about 2 in. above the top. The mounting is made permanent by the use of a standard pipe nipple locked from the top with an electrician's conduit bushing and from the bottom with an electrician's lock nut. The iron is held in the bushing by three setscrews which clamp the body of the iron proper.



Only the insulation contained in the iron itself is required for efficient operation. A perforated sheet-metal guard which encircles the exposed tip permits free circulation of air about the tip, eliminating the possibility of overheating the solder and at the same time assures complete operational safety by guarding against accidental contact with the heated tip.

AUTOMATIC END DUMP HOPPER

A new model, No. 4004 Automatic End Dump Hopper on casters, is announced by H. L. Pitcher Co., exclusive sales agent for the products made by the Rose Mfg. Co., Detroit. When the latch is released and the load is dumped, the bucket is so balanced that it automatically returns and latches in position when reloaded. It rides empty in the balanced position. Mounted on heavy-duty all-steel casters, it is a particularly adaptable unit for the handling of sand, gravel, coal, stampings, small castings and all kinds of scrap and refuse. . . . It is built of welded structural steel and heavy plate, and is designed to fit any kind of lift truck but may be built to specifications as

Three Positions of Hopper: (1) After Dumping Its Load; (2) Empty Position; (3) Loaded Position

to capacity and yardage content. This is the fourth type of dump hopper this company has designed and built, which includes side and three-way entrance dump hoppers.

SMALL TOGGLE CLAMP

A new, small, light duty clamp, which has recently been added to the De-Sta-Co line of toggle clamps, appears especially suitable for use in aircraft construction, or on other work where clamping space is limited.

This new De-Sta-Co clamp measures only 5 1/2 in. in height over-all. It has a base 1 3/8 x 1 3/4 in. Length of bar from handle to tip is 2 1/4 in.

It is made in two styles: model 207S with solid straight bar, and model 207U with U-shape bar.

Descriptive literature will be sent on request, by Detroit Stamping Co., 322 Midland Ave., Detroit, Mich.

DEVICE IMPROVES PROJECTION WELDING

A device which makes practically foolproof the projection welding of steel studs

MEETING TODAY'S NEED

FOR MORE AND FASTER WELDING...

...THE WILSON "BUMBLE BEE" AC WELDER

To keep on top of your heavy 1943 schedules change to AC welding with the new Wilson "Bumble Bee" welder.

This sturdy, efficient Wilson AC machine gives you three advantages that have unusual value today:

1. It increases welding speeds 15% to 25% — particularly on horizontal fillet welding — through use of heavier currents and larger AC electrodes.
2. It cuts power consumption—and costs—as much as 40%, because AC welders eliminate idling loss.
3. It simplifies maintenance because the "Bumble Bee" has no heavy rotating parts that need frequent attention.

Equally important — the "Bumble Bee" can be delivered faster than equivalent dc machines because it requires much less critical materials. Two sizes are available — 300 and 500 amperes. For full details write to Wilson Welder & Metals Co., Inc., 60 East 42nd Street, New York 17, N. Y.

FOR SUPERIOR AC WELDING USE WILSON 530 ELECTRODE

A perfect teammate for the Wilson "Bumble Bee" is the all-position AC electrode — Wilson No. 530. This electrode produces high quality welds to meet the following specifications:

AWS Filler Metal Specification E6011.

Navy Bureau of Ships, Specification 46E3, Grade III, Class I.

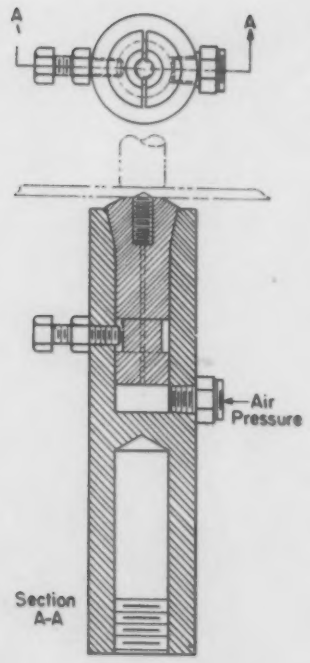
A.S.M.E. Boiler Code, Paragraph U68.

WILSON

WILSON WELDER and METALS CO., INC.

General Offices: 60 East 42nd Street, New York, N. Y.

WILSON AC WELDERS — *distributed exclusively through Air Reduction Sales Co.*



Electrode
For projection weld studs

on metal hinges and sheet metal surfaces has been perfected by Andrew Campriello, a foreman and spot welding expert at General Electric's Schenectady Works.

The device calls for a vertically milled slot in the collet, which is located in the bottom electrode. The collet is tapered. When the stud is introduced in the collet and the upper electrode is depressed, the jaws of the collet close tightly about the stud. The resulting pressure causes the current to be distributed evenly on all sides, and at the top of the stud near the welding zone rather than through the entire stud and then to the sheet.

Below the collet is a space for air, forced in under pressure by a hose. As soon as the welding is complete and the upper electrode lifted, the air pressure forces the tapered collet upward. The collet expands and releases the stud. "Binding" of the stud on release was formerly a problem.

When the collet reaches a height sufficient to release the stud, its movement is stopped by a setscrew which engages the bottom of the collet.

500-LB. CAPACITY WELDING POSITIONER

Designed to handle loads up to 500 lb. with the center of gravity of load 6 in. away from the table top and with a 6-in. eccentricity, the new 500-lb. capacity Welding Positioner introduced by the Ransome Machinery Company, Dunellen, N. J., has many features worthy of note.

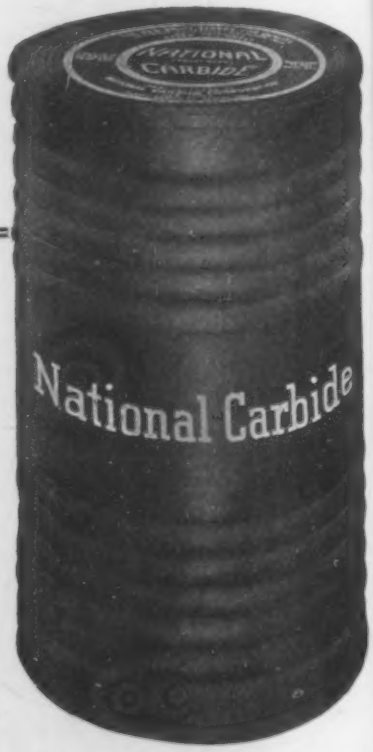
The Positioners are available in hand- or motor-operated models and are particularly suited to work ordinarily handled by women welders. The motorized unit includes a Reeves variable speed drive providing a speed range of up to 1 r.p.m. of the table top. Tilting range is a full 135° from horizontal or 45° beyond vertical providing the "down under" position for all downhand welds.

The 26-in. diameter circular table top is T-slotted simplifying the clamping of work to it. All gears are of the cut-tooth type. The machine can be furnished with a regular base for bench work or with a sub-base giving a height adjustment from 27 in. up to 42 in. from the floor line to the table top. A clutch arrangement permits free rotation of the table top by hand when required. The motorized units can be supplied with a hand wheel in lieu of a motor for tilting if desired.

Bulletin No. 199 illustrating and describing these units will be furnished upon request.

National
Carbide
IN THE RED DRUM

EFFICIENT
ECONOMICAL
DEPENDABLE



FOR WELDING and CUTTING
Use National Carbide in the Red Drum
60 E. 42nd St. NATIONAL CARBIDE CORPORATION New York, N. Y.

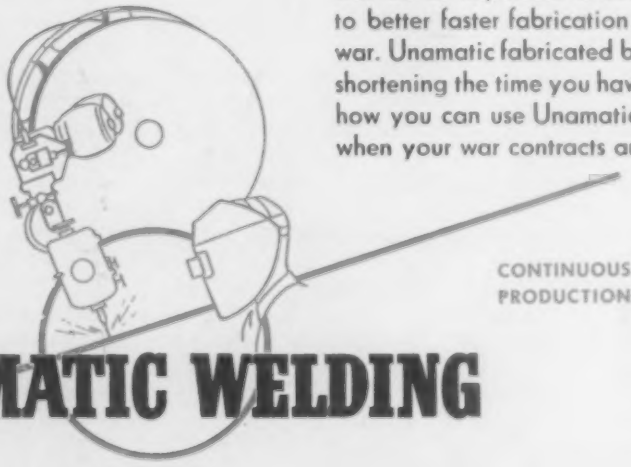
Unamatic Welding Bombs Europe Now—Peace Time Fabrication Next

● Here's a note for history. Among the many elements which brought about the decision to crack Germany from the air a high rating goes to the fact that America had found a way to make bigger bombs faster than anybody had ever dared to hope.

Bombs — both aerial and marine — are being largely fabricated by Unamatic arc welding. Much of the Unamatic equipment going into use the past two years has gone to work on bombs. That's why America is now able to make bombs faster than the planes can drop them.

Circumferential shielded arc welding with Unamatic is the fastest high grade welding known. Down to two inches diameter or six inches straightaway, automatic welding with Unamatic equipment is faster and better and usually costs less than manual operation.

Unamatic equipment now is wholly engaged upon war production. But Unamatic speed and quality will be as important a contribution to better faster fabrication after the war. Unamatic fabricated bombs are shortening the time you have to plan how you can use Unamatic welding when your war contracts are ended.



CONTROLLED QUALITY

CONTINUOUS PRODUCTION

UNAMATIC WELDING

UNA WELDING INC. • 1615 COLLAMER AVE. • CLEVELAND, OHIO

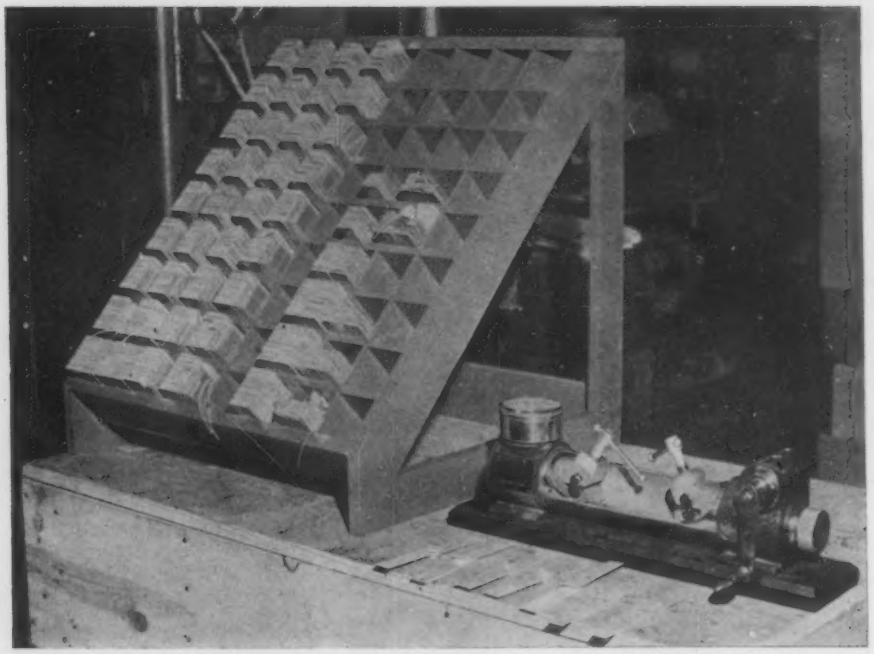


Fig. 1—Shear Testing Machine and Rack for Test Pieces

TESTING SHEAR STRENGTH OF SPOT WELDS

A quick, simple method for shop testing strength and soundness of spot welds has been developed in the East Springfield, Mass., plant of the Westinghouse Electric & Mfg. Co. Spot welding is usually tested by "pulling a button" but this only tells if the material actually welded, failing to give any indication of strength or soundness of weld.

A small shear testing machine is now used to make a thorough test. When an inspector desires to make such a test he takes two standard test pieces, cleans the surfaces and makes the weld by overlapping the two pieces. The welded specimen is then clamped in the machine and a shear is applied. The force applied in pounds is shown by a gage on the machine. A prepared chart shows the minimum strength required for the various thicknesses and types of material.

Advantages gained from the use of the shear testing machine are: (*a*) aids in control of quality by giving a quantitative value of the strength of the weld; (*b*) serves as a quick check on setup of spot welder; (*c*) compact and simple to operate and (*d*) permits tests to be made by operator or floor inspector instead of a laboratory technician.

SAFETY CONTROLS FOR A.-C. ARC WELDERS

Newly developed safety panels, just announced by the Industrial Controller Division of the Square D Company, Milwaukee, Wis., eliminate the hazard created by high open circuit voltages of transformer type A.-C. arc welders.

These new class 8992 panels eliminate any hazard by automatically disconnecting the welder transformer after the arc is broken. The transformer is automatically reconnected the instant the operator touches the electrode to the work. Thus, the arc is struck with no delay. There is

Victory's MAGIC SPARK

☆ Whether it be fixing the drawbar on Jim Beck's tractor, sorely needed on the food front! Or repairin' the axle of Jack Bailey's car that hauls four other workers and himself to Allison's each day! Or performing any of the million and one welding operations in providing armament . . . land, sea and air . . . for Uncle Sam's fighters!

Welding is "Sparking" America to Victory!

As makers of Miller AC Welders, we're proud to be a part of this vital industry. And we pledge you a continuance of Miller ingenuity and craftsmanship that spells *faster* welds, *stronger* welds for you.

For *your* goal and *our* goal are one and the same . . . V-DAY for America!

MILLER ELECTRIC MANUFACTURING COMPANY
Sales: Richmond, Indiana Factory: Appleton, Wisconsin

★ ★ Miller AC Welders ★ ★

Helpful Information on the Use of HAYNES STELLITE HARD-FACING MATERIALS

MATERIAL	PHYSICAL PROPERTIES	PURPOSES FOR WHICH USED	TECHNIQUE POINTERS FOR APPLICATION
HAYNES STELLITE ALLOY No. 1	—red hardness —high abrasion resistance —low coefficient of friction —good corrosion resistance —tensile strength—47,000 lb. per sq. in. —hardness—Rockwell C-54 —coefficient of expansion—similar to steel —hardest of the three grades and most resistant to abrasion.	—For coating surfaces subjected to severe abrasive wear and only slight shock or impact.	***For Steel*** —Remove surface rust or scale. —Preheat part to be faced, if necessary. —Adjust flame so there is an excess of acetylene. The excess acetylene "feather" should be twice as long as the inner cone. —Bring small surface of base metal to a "sweating" condition, insert end of rod into flame and let rod melt and spread over "sweating" area. —Continue applying until entire surface to be faced is built up to required depth. Do not puddle. ***For Cast Iron*** —Similar to steel except use slightly less excess of acetylene. It is necessary to break up the surface "crust" with end of rod. "Ferro" flux is recommended if base metal is dirty.
HAYNES STELLITE ALLOY No. 6	—red hardness —high abrasion resistance —low coefficient of friction —good corrosion resistance —tensile strength—105,000 lb. per sq. in. —hardness—Rockwell C-40 —coefficient of expansion—similar to steel —not as hard as, but tougher than, No. 1 or No. 12. Resistance to abrasion slightly less than No. 12. Does not check easily.	—For coating surfaces subjected to abrasive wear accompanied by considerable impact. Also recommended for cutting edges of hot-work dies. Also for valves of all kinds.	
HAYNES STELLITE ALLOY No. 12	—red hardness —high abrasion resistance —low coefficient of friction —good corrosion resistance —tensile strength—76,000 lb. per sq. in. —hardness—Rockwell C-48 —coefficient of expansion—similar to steel —not quite as hard as No. 1 and slightly less abrasion resistant. Stronger and more ductile; more resistant to impact.	—For coating surfaces subjected to severe wear with enough impact to require more toughness than is possessed by No. 1.	
HAYNES STELLITE "93" ALLOY	—high cold hardness —high abrasion resistance —moderate impact resistance —tensile strength—43,040 lb. per sq. in. —hardness—Rockwell C-62 —coefficient of expansion—similar to steel	—For applications where high cold hardness is necessary and corrosion is not an important factor.	—Use flame half way between that for Hascrome rod and that for Haynes Stellite No. 1, 6, and 12 rod. —Apply like Haynes Stellite No. 1, 6, and 12 rod except that mild puddling is permissible on dirty surfaces or for obtaining an extra smooth surface.
HASCROME ROD	—self-hardening —work-hardening —good abrasion resistance —high impact resistance —tensile strength—40,000 lb. per sq. in. —hardness—Brinell 240 to 500 as deposited depending on application technique. —tougher than Haynes Stellite alloys but not as resistant to abrasion.	—For surfaces subjected to abrasive wear and severe impact. —Makes a very good base for subsequent coating of Haynes Stellite alloys because it resists the mushrooming effect of impact.	—A flame adjustment half way between neutral and that for Haynes Stellite rod No. 1, 6, and 12 is best. —Base metal should be at a "sweating" heat. —Do not puddle. —Use "Ferro" flux if base metal is dirty.
HAYSTELLITE TUBE ROD	—various screen sizes of sharp, irregularly shaped grains contained in tubes of High Test Steel —easily applied by welding flame.	—Where utmost resistance to abrasion is necessary, such as for coating oil well drilling tools.	—Apply so as to avoid deep puddling but to obtain enough penetration to make strongest bond between base metal and binding material.

Send for the free wall chart, "Hard-Facing Materials Data." It includes the above information and other helpful data.

HAYNES STELLITE COMPANY

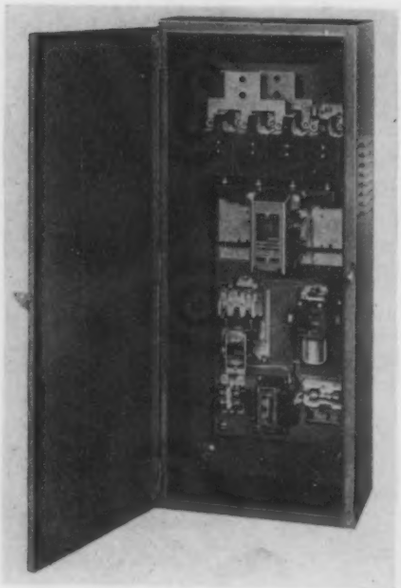
Unit of Union Carbide and Carbon Corporation

New York, N. Y. UCC Kokomo, Indiana

Chicago—Cleveland—Detroit—Houston—Los Angeles—San Francisco—Tulsa

HARD-FACING RODS FOR EVERY PURPOSE

★ ★ Miller AC Welders ★ ★



no loss in operating speed or efficiency.

The manufacturer stresses an economy angle, too When Square D safety panels are used, the welding transformer primary circuit is connected to the power line only while the arc is held. Substantial saving in power is effected when a number of welders are used on a single power system and the power factor is improved.

These new safety panels can be used with any make or model of A.-C. transformer type arc welder. External connections are simple and internal connections of the welder need not be disturbed.

SPOT AND SEAM WELDING DATA FOR LOW CARBON STEELS

The AMERICAN WELDING SOCIETY has recently approved and published a bulletin *Recommended Practices for the Spot and Seam Welding of Low Carbon Steel.* The data contained in this bulletin have been compiled by canvassing approximately 60 fabricators of mild steel structures and resistance welding equipment manufacturers and are intended to meet the needs of the U. S. Navy and War Departments and those in industry engaged in the production of war matériel. The work was initiated by the Resistance Welding Research Committee of the Welding Research Council and has been approved by the Resistance Welding Standards Committee of the AMERICAN WELDING SOCIETY.

The bulletin is composed essentially of two charts—one each for spot and seam welding together with an explanation for their use. For example, after the metal gage is determined, the welding electrode or roll is selected the pressure adjusted and the weld time is set and a pull test made. This is the order in which the data appear from left to right on the charts.

This bulletin represents the best information available at this time on the spot and seam welding of low carbon steel and is therefore recommended as standard practice during the war emergency.

Copies of this bulletin may be obtained from the AMERICAN WELDING SOCIETY, 33 West 39th Street, New York 18, N. Y., in the form of a 4-page leaflet, 6 x 9-in., price 10 cents.

NEW TEMPLATE BOOK AIDS PIPE FITTING

A new 12-page booklet, "Pipe Templates for Welded Fittings," tells how to fabricate fittings for welded piping installations by means of flame-cutting and welding. This illustrated booklet published by the Air Reduction Company shows how to draw up and use paper templates for flame-cutting pipe to assure accurate, close fitting connections.

The templates and procedures described in this booklet are intended primarily for use where special fittings are required or where stock welding fittings may not be available when needed. Although standard welding fittings are generally most economical and efficient, occasions do arise where it is more advantageous for a user to fabricate his own fittings. In such cases the methods outlined in this booklet will save guesswork and spoilage and will help assure efficient fabrication. Free copies of the booklet may be obtained by writing to Mr. G. Van Alstyne, Air Reduction, 60 East 42nd Sts., N. Y.

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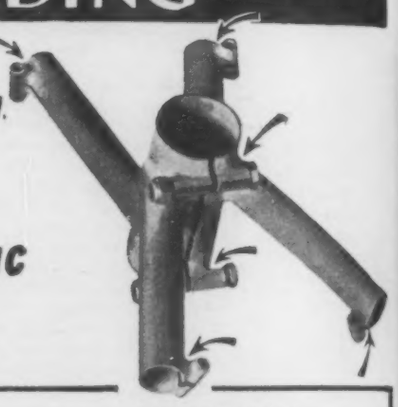

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Bushner, Joseph N. (D), 250 Summer St., Lynn, Mass.
Donnelly, Charles (D), 224 Kelton St., Allston, Mass.
Guanciali, Anthony (D), 43 Cottage St., E. Boston, Mass.
Inman, Chester M. (B), Pratt & Inman, 12 Cherry St., Worcester, Mass.
Kennedy, James W. (D), 162 Medford St., Charlestown, Mass.
Meany, Gerard E. (D), 59 Childs St., Lynn, Mass.
McDaniel, George H., Jr. (D), 503 Main St., Charlestown, Mass.
McLaughlin, Leslie P. (D), 67 Chestnut St., Charlestown, Mass.
Mitchell, Curtis L. (D), 46 Concord Sq., Boston, Mass.
Snow, Norman L. (C), 115 Arlington St., Framingham, Mass.
Whiles, Wm. H. (D), 76 Westwood Rd., Medford, Mass.

CANTON

Petrini, E. G. (C), McNeil Machine & Engrg. Co., 96 E. Crosier St., Akron, Ohio.
Stafford, Howard (C), R. D. 1, Ravenna, Ohio.

CHATTANOOGA

Mitcham, Roy (C), Hotel Patten, Chattanooga, Tenn.

CHICAGO

Burklund, Ted R. (C), 3472 N. Clark St., Chicago, Ill.
Elliott, Everett (C), 606 Lincoln Pk. Blvd., Rockford, Ill.
Haynes, Charles J. (C), % Public Service Co. of No. Ill., Box 278, Glencoe, Ill.
Issel, Michael (B), Automatic Elec. Co., 1033 W. Van Buren St., Chicago, Ill.
Noll, E. E. (C), Public Service Co. of No. Ill., 22 W. Cass St., Joliet, Ill.
Vische, Emil D. (B), National Mineral Co., 2638 N. Pulaski Rd., Chicago, Ill.
Wageck, D. E. (C), Public Service Co. of No. Ill., 1701 So. First Ave., Maywood, Ill.
Young, R. E. (C), % Public Service Co. of No. Ill., 72 W. Adams St., Chicago, Ill.

CLEVELAND

Armington, Raymond Q. (B), 3311 Maynard Rd., Shaker Heights, Ohio.
Capron, Harold R. (C), National Cylinder Gas Co., 3965 Jennings Rd., Cleveland, Ohio.
Clensy, Charles R. (C), 1250 W. 48th St., Ashtabula, Ohio.
Hrabak, Edward (B), 8010 Simon Ave., Cleveland, Ohio.
Roberts, Cederic A. (C), P. O. Box 269, Mantua, Ohio.
Wolf, Salen A. (D), 1280 W. 116th St., Cleveland, Ohio.

COLUMBUS

Buzard, James, (F), 1814 S. High St., Columbus, Ohio.

CONNECTICUT

Newton, Payson T. (D), Farmington, Conn.

DETROIT

Brock, Hiram (C), 2059 Hanford, Lincoln Park, Mich.
Bronson, Charles (C), 75 Oak St., River Rouge, Mich.
Bruce, Albert B. (C), 2420 Poplar, Detroit, Mich.
Buchkoe, Raymond J. (B), State House of Correction and Branch Prison, Marquette, Mich.
Clayton, Arnold (C), 6950 Jim Daly, Dearborn, Mich.
Fullerton, Hugh (C), 14865 Northlawn, Detroit, Mich.
Gaber, Paul J. (B), 2302 Faundale Ave., Flint, Mich.
Giulioli, Gene P. (C), 162 So. Melborn, Dearborn, Mich.
Harris, Herbert D. (C), 7820 Kendal, Dearborn, Mich.
Heldt, Elmer L. (C), 278 Grove, Highland Park, Mich.
Hooberman, Sam (C), 3826 Webb, Detroit, Mich.
Jewell, Leonard (C), 6664 West Point Ave., R. F. D. 5, Dearborn, Mich.
Rose, Vernon G. (C), 12150 Vaughan, Detroit, Mich.
Shanahan, Wm. (C), 16603 Sorrento, Detroit, Mich.
Small, John (C), 5281 Florida, Detroit, Mich.

INDIANA

Nichols, Allen F. (D), 202 N. 18th St., New Castle, Ind.

KANSAS CITY

Rybolt, Myron C. (D), 1905 E. 35th St., Kansas City, Mo.

LOS ANGELES

Baker, Richard I. (D), 222 E. 84th Pl., Los Angeles, Calif.
Rogers, R. M. (B), Thompson Prods., 8354 Wilcox Ave., Bell, Calif.
Ruppert Albert L. (C), 3612 Burton Ave., Lynwood, Calif.
Weid, J. P. (C), 3924 W. 116th St., Hawthorne, Calif.

LOUISIANA

Scott, Arthur M. (B), Ole K. Olsen, Inc., 823 Perdido St., New Orleans, La.

MARYLAND

Lawrence, W. L. (B), Alexander Milburn Co., 1416-28 W. Baltimore St., Baltimore, 23, Md.

MOBILE

Baugh, W. D. (B), Y.M.C.A., Mobile, Ala.
Colvin, Stanley H. (B), 115—Apt. E., Kenowis St., Chickasaw, Ala.
Dave, Coleman W. (B), 308—A Barbour Ave., Alabama Village, Chickasaw, Ala.
Gerhardt, Harold W. (B), 2551 Old Shell Rd., Mobile, Ala.
Misenhamer, William D. (B), Y.M.C.A., Mobile, Ala.
Patterson, John McVicar (B), 254 Ellis Ave., Mobile, Ala.
Tieman, Wm. W. (B), 25 E. N. Circle, Chickasaw, Ala.

NEW YORK

Booth, Leonard (C), 159-13 84th Rd., Jamaica, N. Y.
Marvin, Philip R. (B), 1 Hanson Place, Brooklyn, N. Y.
Neilson, Robert A. (D), Glidden Buick Corp., 3261 Broadway, New York, N. Y.
Rose, Kenneth (B), Metals & Alloys, 330 W. 42nd St., New York, N. Y.
Rucker, Jack (C), 624 E. 31st St., Brooklyn, N. Y.
Shaw, Charles G. (D), 599 Chester St., Brooklyn, N. Y.
Stallings, Robert H. (D), 73 E. 3rd St., New York, N. Y.
Strimel, George H. (B), 73 Station Rd., Irvington, N. Y.

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Carpenter, Miles S. (C), 624 Harrison St., Rahway, N. J.
Cockroft, Edgar (B), Benj. F. Shaw Co., Wilmington, Del.
Davis, Manny (B), Westinghouse E. & M. Co., 1180 Raymond Blvd., Newark, N. J.
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Taylor, Harry (D), 471 E. 26th St., Paterson, N. J.
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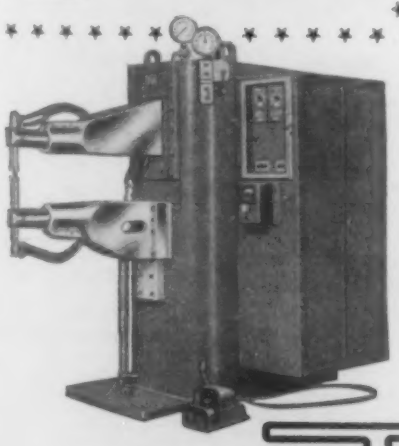

left
TYPE PMCR.2516 SCIAKY ELECTRIC RESISTANCE ROCKER ARM WELDER, welding 70 spot welds per minute, on two sheets of aluminum alloy of .040" each. Welding capacity from two thicknesses of .016" in aluminum alloys up to and including .080".

right
TYPE PMCO.2516 SCIAKY ELECTRIC RESISTANCE WELDER, 80 spot welds per minute on two sheets of light alloy of .040" each. Welding capacity from two thicknesses of .016" each in light alloys up to .091".

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Byrd, Charles A. (C), 1020 S. Henderson St., Galesburg, Ill.
Renner, Rolla L. (C), 552 No. Cherry, Galesburg, Ill.

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Behmke, Wm. (D), 1018 Washington Ave., Woodbury, N. J.
Blachstein, Maxwell (D), 426 Pfeiffer St., Camden, N. J.
Croissette, Charles A. (C), 1292 S. Merrimac Rd., Camden, N. J.
Deily, Richard L. (C), Star Route, Allentown, Pa.
Doran, Wm. A. (C), E. G. Budd Mfg. Co., Navy Dept., Philadelphia, Pa.
Frye, John H., Jr. (C), Lehigh University, Dept. of Met., Bethlehem, Pa.
Hartley, Thomas R. (D), 1618 Summer St., Philadelphia, Pa.
Sadler, Robert L. (C), 3036 South 23rd St. Terrace, Philadelphia, Pa.
Strycharski, Henry (B), 5341 Claridge St., Philadelphia, Pa.

PITTSBURGH

Behr, Gustave C. (C), 35-08 Shadewell Ave., Brentwood, Pittsburgh, 10, Pa.
Lovejoy, Ralph F. (C), R. D. 1, Library, Pa.

PUGET SOUND

Bennett, Robt. D. (D), 4243—6th N. E., Seattle, Wash.

ROCHESTER

Kristensen, Mads H. (B), Big Flats, New York.
Masten, John P. (D), 192 Electric Ave., Rochester, N. Y.
Thomas, Harold L. (D), 754 Plymouth Ave. So., Rochester, N. Y.

SAN FRANCISCO

Daniels, Charles W. (B), 1366 Geneva Ave., San Francisco, Calif.
Hamilton, Ray L. (A), Marinship Corp., Sausalito, Calif.
Roberts, Floyd J. (C), 3177 Vichy Ave., Napa, Calif.

SOUTH TEXAS

Dupree, Edward C. (B), 5611 Clinton Dr., Houston, Tex.
Parrott, H. C. (D), 6522 Pickens, Houston, Tex.

TULSA

Silvers, Floyd L. (C), 1228 S. Quebec, Tulsa, Okla.

WEST MASSACHUSETTS

Ballard, Harry E. (C), 92 College St., So. Hadley, Mass.
Black, Charles R. (C), 43 Forris St., W. Springfield, Mass.
Dyer, Merrill K. (C), 454 Pleasant St., Holyoke, Mass.
Finn. Thos. F. (C), 23 Belvidere Ave., Holyoke, Mass.
Perrine, Raymond T. (C), 75 Penrose St., Springfield, Mass.

WESTERN NEW YORK

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Lorenzini, Anthony (D), 314 E. Oak St., Olean, N. Y.
McNutt, L. R. (D), 55 Tyler St., Buffalo, N. Y.
Quinzio, John R. (B), 210 Delaware St., Tonawanda, N. Y.
Swenson, Donald G. (B), 135 Ruskin Rd., Eggertsville, N. Y.

NOT IN SECTIONS

Bement, G. Willis (B), 4346 S. Detroit Ave., Toledo, Ohio.
Groh, Jack H. (B), 916 Main St., Jacksonville, Fla.
Jenkins, H. Sherman (B), Somerset Machine Shop. Somerset, Ky.
Kappers, Robert J. (B), Ecusta Paper Corp., Pisgah Forest, N. C.
Strayer, Hamilton W. (B), Erie Construction Co., P. O. 1031, Erie, Pa.
Teague, Roland C., Jr. (C), R. F. D. 2 Box 30, Jeffersonville, Ind.
White, Robert L. (C), Mace Rd., Hampton, N. H.

Members Reclassified

During Month of May

MILWAUKEE

Ramsey, James W. (from C to B), 1444 N. Astor St., Milwaukee, Wis.

NORTHERN NEW JERSEY

Adams, Walter F. (from D to C), 114 Montgomery St., Paterson, N. J.
Olson, Albert M. (from D to C), 744 Eaton St., Elizabeth, N J.

NORTHERN NEW YORK

Ballou, Earl M. (from D to C), 1317 Richard St., Schenectady, N. Y.

PHILADELPHIA

Ogden, Russell C. (from D to C), 226 La Carra Dr., Lansdowne, Pa.
Pierce, Harry W. (from C to B), New York Shipbldg. Corp., Camden, N. J.

SAN FRANCISCO

Pellegrin, Leland L. (from D to C), 1330 No. Edison St., Stockton, Calif.
Turi, Ricky (from D to C), 1004 Laguna Ave., Burlingame, Calif.

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SECTION ACTIVITIES

CHICAGO

The May 21st meeting of the Chicago Section was one of the largest and most successful of the 1942–43 season. The meeting was preceded by a dinner and the showing of a travelogue movie on Alaska.

Dr. A. B. Kinzel of Union Carbide and Carbon Research Laboratories was the speaker of the evening. His speech was "The Effects of Alloys in the Weldability of Steel." The speaker, however, digressed somewhat from his subject and described in great detail the work of the War Metallurgical Committee and their recent report "Guide to Weldability of Steel." Following the presentation of his paper there was a lively and interesting discussion of the practicability of the various tests that have been brought out in different recent works of the War Metallurgical Committee.

At the meeting the officers for the coming year were announced. The new officers of the Chicago Section are: *Chairman*, R. L. Kohlbry, Machinery & Welder Corp.; *Vice-Chairman*, H. J. Kircherer, International Harvester Co.; and *Secretary-Treasurer*, T. B. Jefferson, *The Welding Engineer*.

The following were elected directors for a full term of three years: M. W. Hippe, The Linde Air Products Co.; Chas. W. Steele, National Cylinder Gas Co.; Chas. O. Druetzler, Electro-Motive Corp.; and Eric R. Seabloom, Crane Co.

J. C. Menzies was elected director for two years to fill the unexpired term of R. S. Kenrick. Mr. C. J. McGregor was elected as special representative and director of the Chicago Section for a term of one year. The following directors, by virtue of previous elections, continue to hold office: L. C. Monroe, *Welders Digest;* H. M. Downing, Lincoln Electric Co.; C. L. Pfeiffer, Western Electric Co., Inc.; E. P. Everhard, Wm. A. Pope Co.; C. G. Bassler, Taylor-Winfield Corp.; E. J. DeWitt. Wallace Supplies Mfg. Co.; and Matt H. Wigton, Bastian-Blessing Co.

CINCINNATI

The Cincinnati Section announces the election of the following officers: *Chairman*, Tom Raftery *Vice-Chairman*, George Jacoby; *Treasurer*, Rowan Gilreath; *Secretary*, Ernest F. Cahn; and *Executive Committee* (*New Members*): L. T. Kinney, Wm. Pahner, H. Christa Smith; (*Old Members*): Larry Sherman, R. Krauss, H. K. DeVries.

DETROIT-FLINT DIVISION

The Flint Division held their final activity for the season on Saturday, May 22nd. It was in the form of a dinner dance and was a splendid get-together. They had justification for celebrating their first year's activities.

The following officers were elected: *Chairman*, L. M. Skidmore, General Motors Institute; *Vice-Chairman*, Ralph Hill, Ordnance Corps; and *Secretary-Treasurer*, E. A. Fisher, Fisher Tank Div.

LOS ANGELES

C. W. Johnson, Asst. Supt. of welding of the California Shipbuilding Corp., was the speaker at the May meeting. In his speech he featured a review of welding instructional work in shipyards. The talk was extremely interesting and he pointed out some very pertinent facts regarding streamlined instruction for students. Mr. Johnson is collaborating with another shipyard in publishing a book for the State of California Educational Department covering instructions in shipyards.

MARYLAND

The May 21st meeting was addressed by Mr. David C. Boltz, Sales Engineer for the Metallizing Engineering Co. The explanation of the use and uses for metal spraying was most interesting and instructive.

The meeting was also the Annual Meeting at which the following officers were elected for the coming year: *Chairman*, Van Rensselaer P. Saxe; *Vice-Chairman*, C. N. Hilbinger; *Secretary-Treasurer*, Donald A. Darr; and *Members of Executive Committee*, Thomas J. Griffin, Elisha A. Brown, Wesley H. Shaprow and Roy A. Mansfield.

NORTHERN NEW YORK

The Northern New York Section reports the election of the following officers for the coming year: *Chairman*, E. R. Spittler; *1st Vice-Chairman*, H. S. Swan; *2nd Vice-Chairman*, H. O. Westendarp; *Secretary-Treasurer*, R. S. Pelton; and *Directors*, A. F. Siglmeier, R. A. Gilbert, C. I. MacGuffie, E. F. Potter, J. E. Waugh, and M. F. Sayre.

OKLAHOMA CITY

M. C. Robbins of Handy and Harman, was the principal speaker at the May 7th meeting of this Section. Mr. Robbins' talk and demonstration on "Silver Brazing as Applied to War Work in Industry" proved to be one of the most interesting of the season.

The Section is indebted to the local Air Reduction Sales Co., at whose plant the meeting was held, for making possible this meeting and acting as host. Refreshments were served and a good time was had by all.

PHILADELPHIA

On Monday evening, May 17th, the Philadelphia Section held a post-season meeting on the subject of "Welding in Aircraft Production." This meeting had originally been scheduled for January but, because of conflict on dates with the first panel discussion meeting held at the Boardwood Hotel, and in view of the speaker's kindness in postponing his visit, was held over until this time. Nevertheless, the lecture by P. H. Merriman which followed the general meeting presented a marvelous climax to a year of complete success. In conjunction with his talk, Mr. Merriman presented two reels of motion pictures illustrating resistance welding applications in aircraft production at the Glenn L. Martin plant in Baltimore and it was only a result of the necessity for some of those present to catch early trains that the meeting was officially closed at 10:15. Others retired to the rear of the room to partake of the Fellowship Committee's refreshments and actual discussion of the evening's subject, to which Mr. Merriman proved a reservoir of valuable information.

The third and last panel discussion meeting for the season, sponsored by the Philadelphia Section, A.W.S., under the guidance of Mr. Bower, *Chairman*, Coordinating Committee of the Affiliated Societies Council of Philadelphia, was held on Friday evening, May 28th, the panel consisting of: W. W. Barnes, Air Reduction Sales Co. (Ret.), *Chairman;* A. J. Raymo, Welding Engineer, Baldwin-Southwark Corp.; A. L. Deane, Asst. Foreman, New York Shipbuilding Corp.; E. D. Hecox, Welding Engineer, Cramp Shipbuilding Co., and H. J. Irrgang, Supt., W. K. Mitchell Co.

Following short talks on "Shop Problems in Alloy Steel Welding" by Mr. Raymo, and "Shrinkage and Close Tolerance Control in Heavy Weldments" by Mr. Deane, the meeting, attended by over a hundred members and guests, was thrown open for general discussion, which delved into preheating, welding of bronze and bronze castings, methods of overcoming distortion due to welding, peening, stress relieving and a host of other allied subjects, and closed at 10:30 after two and one-half hours of lively and informative discussion.

While the Philadelphia Section has not conducted any form of training or series of courses during the current season just closed the three panel discussion meetings which have been held to date have proved very beneficial and gratifying, and as educational as any other form could possibly be. The Section is looking forward to continuing this form of discussion group next season.

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Second, the number of *good* welds per hour depends, first, last, and always, on the *quality* of the electrodes and how well their *characteristics fit the requirements of the job.* When the electrodes which provide the most desirable characteristics have been found, it is very important that these characteristics be duplicated in subsequent orders.

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PITTSBURGH

The Sixth Annual Tri-State Welding Conference of the Pittsburgh Section sponsored jointly with the Engineers' Society of Western Pennsylvania was held Friday night, April 30th, in the Mellon Institute of Industrial Research Auditorium.

The meeting was preceded by a splendid "get-together" dinner in the Webster Hall Hotel at which time nearly one hundred members and guests were addressed by J. H. Humberstone, Divisional Vice-President, on the subject of the work the AMERICAN WELDING SOCIETY is doing and an outline of the many duties of the various committees and the cooperation of the parent body with the Sections.

Newly elected officers for the 1943–44 season were announced as follows: *Chairman*, C. H. Jennings, Westinghouse Elec. & Mfg. Co.; *Vice-Chairman*, G. O. Hoglund, Aluminum Co. of America; *Secretary* J. F. Minnotte, Minnotte Brothers Co.; and *Executive Committee*, A. J. Deacon, Glenn J. Gibson and Harry P. Schane.

Following the dinner the Conference was held in the Auditorium and nearly two hundred members and guests heard Norman G. Schreiner, Unionmelt Div. Engineer of The Linde Air Products Co. of New York, give a most thorough discussion of the subject of "Shipbuilding by the Unionmelt Process." His discussion dealt with particular reference to the technique and procedure pertaining to shipbuilding. Both films and slides were used to illustrate the talk following which the meeting was thrown open to general discussion.

Announcement was made of the passing of George H. Danforth, recently in Margate, N. J., where he resided since his retirement from the Jones & Laughlin Steel Corp. Mr. Danforth served as Secretary of the Pittsburgh Section for many years and was most active in the establishment and operation of the Pittsburgh Section.

SAN FRANCISCO

The regular monthly meeting of this Section for May was held on the 28th. "Flame Hardening and Flame Softening" was presented by O. L. Nixon, Service Operator of The Linde Air Products Co. This presentation consisted of a motion picture and slide films, with a running commentary by Mr. Nixon on the important subjects of flame hardening and flame softening. It included a detailed description of the fundamental technique as well as illustrations of numerous plant operations. Among the interesting items featured were the flame hardening of tank sprockets, flame hardening of gears and the world's largest roll hardening machine.

SAVANNAH

A dance sponsored by the Savannah Section was held at the Shrine Country Club in Savannah on May 25th. Such a fine time was enjoyed by members and guests that it was planned to hold another dance on July 18th.

L. B. Ely, Manager of Process Service for the Southern Div. of The Linde Air Products Co. was the guest speaker at the June 9th meeting. Mr. Ely presented a demonstration of movies on plate edge preparation and Unionmelt welding.

SOUTH TEXAS

The South Texas Section held its annual meeting on May 20th at the Houston Engineers' Club. Two good motion pictures on the different phases of steel making were shown through the courtesy of the Bethlehem Steel Co.

An election of officers was also held with the election of the following: *Chairman*, W. T. Hudson; *Vice-Chairman*, E. C. Jackson and *Secretary-Treasurer*, A. E. Wisler.

TOLEDO

A preliminary meeting for the purpose of forming a Toledo Section of the AMERICAN WELDING SOCIETY was held on May 28th, attended by the following members: Lorenzo Kennon, G. C. Robinette, E. Barnes, J. Sheely and G. W. Bement.

At the first meeting of the Section held on June 2nd in the Commodore Perry Hotel, the temporary officers, appointed at the May 28th meeting, were, by unanimous vote, made permanent officers, to hold office until June 1, 1944.

These officers are: *Chairman*, Lorenzo Kennon, Consulting Engineer, Willys-Overland Motors, Inc.; *1st Vice-Chairman*, A. Holle Homrighaus, Manager, Welder Service Co.; *2nd Vice-Chairman*, R. V. Mills, General Master Mechanic, Willys-Overland Motors, Inc.; *Secretary-Treasurer*, C. M. Richardson, Manager, Lincoln Electric Co.; and *Executive Committee*, Anthony Menna, Manager, Menna Welding Co.; Manuel Nardiello, Manager, Toledo Testing Lab., and John Geisland, Welding Engineer, City Auto Stamping Co.

The first meeting was a great success and the enthusiasm shown should result in a large increase in membership.

WESTERN MASSACHUSETTS

The May meeting of this Section was held at the Holyoke Y.M.C.A. on Monday, May 31st. Mr. W. D. Halsey, Assistant Chief Engineer of the Boiler Div., Hartford Steam Boiler Inspection and Insurance Company, spoke on "Qualification of Welding."

YORK-CENTRAL PENNA.

On May 19th the York-Central Penna Section held its monthly meeting at the Engineering Society of York Building, York, Pa. J. A. Cunningham, the speaker of the evening, spoke on the subject of Hard Facing. Mr. Cunningham had a very interesting collection of slides which further illustrated this timely subject.

An added attraction was the showing by Paul Lang of movies on "How to Weld Upside Down Without an Umbrella."

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BOARD OF DIRECTORS MEETING

A meeting of the Board of Directors was held in New York on June 10th with the following present, K. L. Hansen, *President*, presiding:

Directors: C. A. Adams, H. C. Boardman, R. W. Clark, E. V. David, J. H. Deppeler, E. R. Fish, Isaac Harter, H. O. Hill, J. H. Humberstone, G. F. Jenks and F. L. Plummer. *Members Executive Committee:* W. E. Crawford, D. S. Jacobus, J. F. Lincoln and H. M. Priest. *By Invitation:* W. F. Hess, *Chairman*, Awards Committee; G. N. Sieger, *Chairman*, Membership Committee; R. D. Thomas, *Chairman*, Section Advisory Committee. *Others:* W. Spraragen, *Editor*, THE WELDING JOURNAL; and M. M. Kelly, *Secretary*.

Technical Activities

It was voted: To approve recommendation that the A.W.S. accept invitation to membership on the A.S.A. Sectional Committee Z10 on Standardization of Letter Symbols and Abbreviations; that W. Spraragen, *Editor* of THE WELDING JOURNAL, be designated as the A.W.S. representative on this Committee with S. A. Greenberg, Assistant Technical Secretary, as alternate; and, that W. Spraragen be requested to study the activities of the various Subcommittees of A.S.A. Sectional Committee Z10, with a view to recommending the desirability of A.W.S. representation on them.

It was voted: To approve recommendation for the discharge of the Committee on Arc Welding Standards for Shop Erected Low Alloy Structures Subject to Dynamic Stresses.

It was voted: To approve recommendation that paragraph 12 of the Rules to Govern Technical Committees (published in 1942 Year Book) be revised to read:

"Officers of Technical Committees shall be elected for terms of two years. Prior to expiration of the officers' terms of office, the Chairman of each Technical Committee shall arrange for an election of officers to serve for the ensuing two years. In case of failure of any Technical Committee to elect officers, it shall be the privilege of the Committee on Outline of Work to designate the new officers."

Aluminum Specifications

The Outline of Work Committee Chairman reported that they have been approved by the A.W.S.-A.S.T.M. Filler Metal Subcommittee on Aluminum and Aluminum Alloys, the Committee on Filler Metal and the Outline of Work Committee, and it is now desired that they be approved for publication as a Tentative Standard of the SOCIETY.

It was voted that the Tentative Specifications for Aluminum and Aluminum Alloy Metal Arc Welding Electrodes be approved for publication as a SOCIETY standard.

EDITORIAL NOTE: These Specifications have been published in the 1942 A.W.S. *Welding Handbook*.

Safe Practices for Welding and Cutting Operations

On recommendation of the acting Technical Secretary, the Secretary of the SOCIETY was directed to inform the A.S.A. of the intention of our SOCIETY to join with N.E.M.A. and I.A.A. in preparing a draft of a Code of Safe Practices for welding and Cutting, which will be offered to the A.S.A. for approval and with request that it be issued under the American War Standards Procedure. It is understood that a similar request for the development of an American War Standard on the control of welding hazards has been received by the A.S.A. from the U. S. Department of Labor.

Finances

Request for permission to add another member to the staff, who could do stenographic and clerical work, was approved.

By-Law Changes

A number of changes in the By-Laws were approved. This action formed one of the principal items of business at the Board of Directors meeting. A full account of the proposed changes is published elsewhere in this JOURNAL.

Section Advisory Committee

Suggestion was made that consideration be given to a revision of the present setup of the Section Advisory Committee. Some members of the Board expressed the thought that perhaps the functions of the Section Advisory Committee could be taken over by the District Vice-Presidents. The matter was referred to the Section Officers Conference for further consideration and recommendation to the Board of Directors.

Revised Membership Application Form

A revised membership application form submitted by the Section Advisory Committee in consultation with the Membership Committee was approved.

Requests for Welding Publications from Foreign Libraries

Report of the Special Committee on handling requests for welding publications coming from foreign libraries, was considered and the recommendations of the Committee were approved. These recommendations are:

1. That definite plan of action be postponed until probable postwar outlook is clear.
2. That for the time being special requests be handled separately and on their merits.
3. That special requests for *Welding Handbook* up to 10 copies be granted at discretion of Secretary.
4. That SOCIETY's efforts on behalf of foreign libraries in the future be limited strictly to A.W.S. publications, and in preparation for postwar action. Steps be taken now to promote voluntary return to SOCIETY Headquarters of back numbers of THE WELDING JOURNAL and Research Supplement by requests and explanation in THE WELDING JOURNAL, to be repeated at suitable intervals.
5. That Special Committee be continued in office to deal with this problem until need no longer exists. Continuation of Committee should be names of following offices: Treasurer, A.W.S.; Chairman, Publications Committee, A.W.S.; and Editor, THE WELDING JOURNAL.

Permanent Funds of the Society

In the absence of the Chairman of the Committee, Mr. Harter read report of the Special Committee for Building Up Permanent Funds of the SOCIETY. He drew attention to the table accompanying the report, in which comparisons were made between the permanent funds of the A.W.S. and those of nine other technical societies, on the basis of dues in reserve per member and relationship of permanent funds to the annual cost of operation.

On motion, it was voted that the Special Committee on Permanent Funds be authorized to proceed with the proposed campaign for building up the permanent funds of the SOCIETY and that this Committee be delegated the necessary authority to develop a detailed plan preparatory to getting the campaign under way as soon as possible.

Adams Lectureship

In connection with the award of the Adams Lecture, rules were adopted. These rules will be published in the next issue of the JOURNAL.

Membership

In reporting on the splendid growth of membership during the past year, the Membership Committee Chairman took occasion to express gratitude to the Sections, his Committee members and Headquarters for their fine work in promoting the SOCIETY; to P. R. Mallory, The Lincoln Electric Company and Metal & Thermit Corp., for the preparation of membership ads and to *Industry & Welding*, *The Welding Engineer* and THE WELDING JOURNAL for donating space in their publications for the ads; he reported on the increased interest in welding in different parts of the country which is resulting in the organization of many new Sections. He stressed the importance of the membership activity and pointed out the need for assistance in furnishing attractive Section meetings and getting the right kind of speakers which, in his opinion, is one of the best means of obtaining new members and retaining present ones.

He emphasized the need also for cooperation from the Directors and influential members of the SOCIETY in spreading good will throughout the country by contacting Section Officers when visiting towns where there are Sections and by offering to talk before Sections, especially in remote parts of the country where it is most difficult to get outside speakers.

He stated that his Committee is giving consideration to a program of activity which can be expanded or reduced, according to the money made available. It was suggested that the Membership Committee Chairman consult with the Finance Committee on his Committee's plans for next year's activities.

The membership report was enthusiastically received and Mr. Sieger was thanked for his efforts.

Sections—CHAIRMEN, SECRETARIES AND REGULAR MEETING DATES

ATLANTA — 1st Fri.

CHAIRMAN—MICHAEL C. STELLMAN, 1164 N. Highland Ave., N. E. Atlanta, Ga.

SECRETARY—J. V. TURNER, Air Reduction Sales Co., 336 Spring St., N. W., Atlanta, Ga.

BIRMINGHAM — 3rd Fri.

CHAIRMAN—C. C. PINCKNEY, Birmingham Boiler & Eng. Co., 41st St. & 8th Ave., North, Birmingham, Ala.

SECRETARY-TREASURER—W. L. POOLE, Air Reduction Sales Co., 2825 N. 29th Ave., Birmingham, Ala.

BOSTON — 2nd Mon.

CHAIRMAN—F. W. DAVIS, E. B. Badger & Sons Co., 75 Pitts St., Boston, Mass.

SECRETARY—P. N. RUGG, 22 Eastern Ave., Wakefield, Mass.

CANAL ZONE — 1st Tues.

CHAIRMAN—CLIFFORD B. JONES, Box 533, Diablo Heights, Canal Zone

SECRETARY—R. E. HOLLICK, Box 924, Diablo Heights, Canal Zone

CHATTANOOGA, TENN. — 1st Wed.

CHAIRMAN—P. O. LEACH, Combustion Engineering Co., 1032 W. Main St., Chattanooga, Tenn.

SECRETARY-TREAS.—R. G. WILSON, National Cylinder Gas Co., 1410 Cowart St., Chattanooga, Tenn.

CHICAGO — 3rd Fri.

CHAIRMAN—R. L. KOHLBRY, Machinery & Welder Corp., 312 N. Loomis St., Chicago, Ill.

SECRETARY—T. B. JEFFERSON, *The Welding Engineer*, 506 S. Wabash Ave., Chicago, Ill.

CINCINNATI, OHIO

CHAIRMAN—TOM RAFTERY, The Linde Air Prod. Co., 2506 May St., Cincinnati, Ohio

SECRETARY—ERNEST F. CAHN, Ohio Valley Sales Co., 3018 Robertson Ave., Cincinnati, Ohio

CLEVELAND — 2nd Wed.

CHAIRMAN—R. J. KRIZ, James Herron Co., 1360 W. 3rd St., Cleveland, Ohio

SECRETARY-TREAS.—A. LESLIE PFEIL, Universal Power Corp., Cleveland, Ohio

COLUMBUS, OHIO — 2nd Fri.

CHAIRMAN—CLAY W. ROBERTS, Pennsylvania R. R., Columbus, Ohio

SECRETARY—G. S. HERREN, The Seagrave Corp., Columbus, Ohio

CONNECTICUT — 1st Tues.

CHAIRMAN—B. H. PERRY, Bigelow-Sanford Carpet Co., Thompsonville, Conn.

SECRETARY—J. IMPERATI, American Brass Co., Ansonia, Conn.

DETROIT — 1st Fri.

CHAIRMAN—EARL H. FOSS, 7239 Kentucky Ave., Dearborn, Mich.

SECRETARY—G. N. SIEGER, S-M-S Corp., 1165 Harper Ave., Detroit, Mich.

HAWAII — Last Thurs.

CHAIRMAN—GEORGE GLOVER, W. A. Ramsay, Ltd., Honolulu, T. H.

SECRETARY—ALAN G. SLIPPER, Hawaiian Gas Products Co., P. O. Box 2454, Honolulu, T. H.

INDIANA — 3rd Fri.

CHAIRMAN—E. F. GILYEAT, J. D. Adams Mfg. Co., Indianapolis, Ind.

SECRETARY—H. D. WEED, P. R. Mallory & Co., Indianapolis, Ind.

KANSAS CITY, MO. — 1st Tues.

CHAIRMAN—EDGAR H. FINLAY, Finlay Engineering College, 1001 Indiana Ave., Kansas City, Mo.

SECRETARY—DUANE DE BRUNNER, Columbian Steel Tank Corp., 1509 W. 12th St., Kansas City, Mo.

LAKE SHORE

CHAIRMAN—FRED HERBST, JR., McMullen & Pitz Construction Co., 923 Commercial St., Manitowoc, Wis.

LOS ANGELES — 3rd Thurs.

CHAIRMAN—ALEX MARADUDIN, Standard Oil Co., El Segundo, Calif.

SECRETARY—E. O. WILLIAMS, Victor Equipment Co., Los Angeles, Calif.

MARYLAND — 3rd Fri., except April

CHAIRMAN—VAN RENSSELAER P. SAXE, 100 W. Monument St., Baltimore, Md.

SECRETARY-TREAS.—DONALD A. DARR B. & O. R. R., B. & O. Central Bldg., Rm. 609, Baltimore, Md.

MILWAUKEE — 3rd Fri.

CHAIRMAN—KEITH WALKER, 3721 S. Herman St., Milwaukee, Wis.

SECRETARY—GILBERT F. MEYER, Machinery & Welder Corp., Milwaukee, Wis.

MOBILE

CHAIRMAN—W. A. PIERRE, JR., 1258 S. Ann St., Mobile, Ala.

SECY.-TREAS.—W. P. BOLEN, 18 Gladys Ave., Mobile, Ala.

NEW YORK — 2nd Tues, except when Joint Meeting is held

CHAIRMAN—G. SCHNEIDER, Acetylene Welding & Equip. Co., 1065 Atlantic Ave., Brooklyn, N. Y.

SECRETARY—GEORGE SYKES, The Linde Air Products Co., General Publicity Dept., 30 E. 42nd St., New York, N. Y.

NORTHWEST — 3rd Wed.

CHAIRMAN—JOHN MIKULAK, Electric Machinery Mfg. Co. 1331 Tyler St. N. E. Minneapolis, Minn.

SECRETARY—ALEXIS CASWELL, Manufacturers' Assoc. of Minn., 200 Builders Exchange Bldg., Minneapolis, Minn.

NORTHERN NEW JERSEY — 3rd Tues.

CHAIRMAN—T. B. SMITH, Federal Shipbuilding and Drydock Co., Kearny, N. J.

SECRETARY—W. H. HART, Chas. W. Krieg Co., 52-60 Dickerson St., Newark, N. J.

NORTHERN NEW YORK — Last Thurs.

CHAIRMAN—E. R. SPITTLER, 6 Cornelius Ave., Schenectady, N. Y.

SECRETARY—R. S. PELTON, General Electric Co., Schenectady, N. Y.

OKLAHOMA CITY — First Thurs.

CHAIRMAN—FRANCIS SPREHE, Midwest Steel Co., 2 N. Indiana Ave., Oklahoma City, Okla.

SECRETARY—HOWARD N. SIMMS, Box 1714, Oklahoma City, Okla.

PEORIA—CENTRAL ILLINOIS

CHAIRMAN—CLIFFORD WIMMER, 1104 Ann St., Peoria, Ill.

SECRETARY—A. RUNKEL, R. G. LeTourneau, Inc., Peoria, Ill.

PHILADELPHIA — 3rd Mon.

CHAIRMAN—H. W. PIERCE, New York Shipbuilding Corp., Camden, N. J.

SECRETARY—H. CAREY BOSS, 248 Rhoads Ave., Haddonfield, N. J.

PITTSBURGH — Middle Wed.

CHAIRMAN—C. H. JENNINGS, Westinghouse Elec. & Mfg. Co., Pittsburgh, Pa.

SECRETARY—J. F. MINNOTTE, Minnotte Bros Co., 1201 House Bldg., Hays (7) Pittsburgh, Pa.

PUGET SOUND

CHAIRMAN—SYDNEY K. SMITH, American Bureau of Shipping, 1727 Exchange Bldg., Seattle, Wash.

SECRETARY-TREAS.—JOHN NELSON, Air Reduction Sales Co., 3623 E. Marginal Way, Seattle, Wash.

ROCHESTER, N. Y. — 1st Thurs.

CHAIRMAN—EVERETT L. HAND, Gleason Works, 1000 University Ave., Rochester, N. Y.

SECRETARY—HAROLD J. KING, University of Rochester, Engineering Dept., Rochester 3, N. Y.

SAN FRANCISCO — Last Fri.

CHAIRMAN—ROBERT O. WALDMAN, Chicago Steel & Wire Co., 1043 Bryant St., San Francisco, Calif.

SECRETARY—R. E. LABAGH, Victor Equipment Co., 844 Folsom St., San Francisco, Calif.

ST. LOUIS — 2nd Fri.

CHAIRMAN—A. S. SCHWARZ, John Nooter Boiler Works Co., St. Louis, Mo.

SECRETARY—H. C. CLOSE, Machinery & Welder Corp., 700 S. Spring Ave., St. Louis, Mo.

SAVANNAH

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SECY.-TREAS.—J. R. COWART, Southeastern Shipbuilding Corp., Savannah, Ga.

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SECRETARY-TREAS.—A. E. WISLER, Hughes Tool Company, 300 Hughes St., Houston, Texas.

TOLEDO

CHAIRMAN—LORENZO KENNON, Willys-Overland Motors, Inc., Toledo, Ohio

SECRETARY—C. M. RICHARDSON, Lincoln Electric Co., Toledo, Ohio

TULSA, OKLA.

SECRETARY—JAMES B. DAVIS, Tulsa Testing Labs., Tulsa, Okla.

WASHINGTON, D. C. — 2nd Tues.

CHAIRMAN—H. L. INGRAM, JR., Air Reduction Sales Co., 1823 L St., N. W., Washington, D. C.

SECRETARY—B. J. BRUGGE, 410 Hill Building, 17th and I Sts., N. W., Washington, D. C.

WESTERN NEW YORK — 3rd Fri.

CHAIRMAN—JOHN BOS, JR., 60 Westfield Rd., Eggertsville, N. Y.

SECRETARY—R. S. LANE, Ross Heater & Mfg. Co., 1407 West Ave., Buffalo, N. Y.

WESTERN MASSACHUSETTS

CHAIRMAN—WILLARD A. EMERY, Worthington Pump & Machinery Co., Holyoke, Mass.

SECRETARY—J. J. KAPINOS, Worthington Pump & Machinery Co., Holyoke, Mass.

WICHITA, KAN.

SECRETARY-TREAS.—R. L. TOWNSEND, 266 Minneapolis St., Wichita, Kan.

YORK—CENTRAL PA.

CHAIRMAN—E. E. ROUSCHER, A. B. Farquhar Co., York, Pa.

SECRETARY—C. E. LEWIS KERCHNER, 290 W. Cottage Place, York, Pa.

YOUNGSTOWN, OHIO — 2nd Mon.

CHAIRMAN—ROBERT FISHER, 1534 Thomas Road, Warren, Ohio

SECRETARY—CARL J. HELTZEL, Heltzel Steel Form & Iron Co., Warren, Ohio.